QE
701
.J8
Cop 2

Volume 1 JANUARY 1928 Number 4

E. O. Case Univ. of Mich.
Ann Arbor, Mich.

JOURNAL OF Paleontology

CONTENTS

An Aid in Disintegrating Samples for Micro-Organic Study
By Herschel L. Driver 253

The Age and Origin of the Shawangunk Formation
By Bradford Willard 255

Silicoflagellata from the Cretaceous of California
By G. Dallas Hanna 259

A New Species of *Bolivinita* from the Lower Pliocene of California
By C. C. Church 265

A New Nonion from Peru - - - *By E. Willard Berry* 269

A Group of Foraminifera from the Canyon Division of the Pennsylvanian Formation in Texas - - *By James A. Waters* 271

Species of Large Arenaceous and Orbitoidal Foraminifera from the Tertiary Deposits of Jamaica *By Thomas Wayland Vaughan* 277

Notes on the Genus *Polylepidina* and a New Species
By J. J. Galloway 299

Pennsylvanian Foraminifera of Oklahoma and Texas
By Bruce H. Harlton 305

Report of the Fort Worth Section Meeting *By W. M. Winton* 311

The Earth and Its Rhythms (a Review) - - - - - 313

JOURNAL OF PALEONTOLOGY

JOSEPH A. CUSHMAN, *Editor*

The Journal of Paleontology will be published four times a year by the Society of Economic Paleontologists and Mineralogists, at the University of Chicago Press, 5750 Ellis Avenue, Chicago, Illinois. Owing to delays consequent upon the forming of the new Society, the numbers for Volume 1 will not bear the regular dates that it is hoped can be started with Volume 2. It is expected that four numbers will be published in the calendar year 1927, July, August, October, and December.

The subscription price to other than members of the Society is $6.00 per year prepaid to addresses in the United States, Mexico, Cuba, Porto Rico, Panama Canal Zone, Republic of Panama, Dominican Republic, Canary Islands, El Salvador, Argentina, Bolivia, Brazil, Colombia, Chile, Costa Rica, Ecuador, Guatemala, Honduras, Nicaragua, Peru, Haytí, Uruguay, Paraguay, Hawaiian Islands, Philippine Islands, Guam, Samoan Islands, Balearic Islands, and Spain.

Postage is charged extra: For Canada, 20 cents on annual subscriptions (total $6.20), and for all other countries in the Postal Union, 40 cents on annual subscriptions (total $6.40).

Claims for non-receipt of preceding numbers of the JOURNAL must be sent to the secretary-treasurer within three months of the date of publication in order to be filled gratis.

The JOURNAL will furnish reprints at cost. Orders should accompany corrected galley proof.

Communications about the JOURNAL, subscriptions, rates, memberships, change of address, and advertising should be addressed to

MARCUS A. HANNA, *Secretary-Treasurer*
DRAWER C
HOUSTON, TEXAS

Communications in regard to manuscripts or purely editorial matters should be addressed to

JOSEPH A. CUSHMAN
76 BROOK ROAD
SHARON, MASSACHUSETTS

PRINTED AT THE UNIVERSITY OF CHICAGO PRESS, U.S.A.

Volume 1 Number 4

JOURNAL OF PALEONTOLOGY

JANUARY 1928

AN AID IN DISINTEGRATING SAMPLES FOR MICRO-ORGANIC STUDY[1]

HERSCHEL L. DRIVER
Los Angeles, California

One of the first problems confronting workers on micro-organisms is the need of a rapid method of freeing organisms from samples so that they may be identified. The method herein discussed, of boiling the samples under pressure, has, in general, been found to be rapid and to leave any organisms present relatively free of adhering matrix.

A pressure cooker manufactured for culinary purposes is adaptable to the process. The cooker in use by the writer measures 9 inches in diameter and 6 inches in depth. Four 400-cc. beakers may be readily accommodated. The cooker is provided with a cover upon which is attached a gauge, reading up to 30 pounds pressure; an exhaust valve; and a safety valve. The latter is set to release at an approximate gauge pressure of 22 pounds. The temperature at which boiling takes place is a direct function of pressure so that the operating temperatures vary up to 260° F.

In applying the cooker to this purpose, about 1 inch of water is added, and enough water is placed in the beakers to cover the samples. Heat is applied by means of an electric hot plate. The exhaust valve is not closed until the container is full of steam. About 15 minutes are required with maximum heat to reach a pressure just under that for which the safety valve is set. This time interval has been found to be sufficient to break down many of the samples. Low heat is applied to the harder samples after the maximum operating pressure is attained, so that the material may be under the influence of increased temperature and pressure for a longer period of time.

Care must be taken to release the pressure slowly so as to avoid excessive boiling which might result in contamination.

This method is amenable to all but the most thoroughly indurated material. Some samples may more or less retain their original shape after treatment, but a close inspection usually reveals numerous cracks along which the sample breaks

[1] Published with permission of Standard Oil Company of California.

down during a subsequent process of screening, crushing, or mechanical attrition. Any sample which can be broken down by merely boiling may be disintegrated to at least an equal extent within a shorter interval of time by the pressure-cooker process.

An additional advantage is the practical elimination of the tendency of many micro-organisms, especially Foraminifera, to float owing to the entrapment of air. This advantage is of importance since the more perfect organisms are the most liable to contain entrapped air and float away during the process of washing or to cause difficulties of extraction when wet methods are employed.

A further refinement of this apparatus for disintegrating samples would be an automatically controlled heating unit and pressure chamber placed within a fireless cooker, thereby permitting of extended intervals of operation, where necessary, with a minimum of heat consumption and without the need of frequent attention.

THE AGE AND ORIGIN OF THE SHAWANGUNK FORMATION

BRADFORD WILLARD
Brown University

INTRODUCTION

Although the Shawangunk conglomerate has been studied by geologists for almost a century, there still remains some disagreement as to the age of the formation. In the present paper the author wishes to give certain conclusions at which he has arrived after considerable study of this horizon in New Jersey and Pennsylvania.

The Shawangunk formation extends from southeastern New York State, across northern New Jersey and thence nearly due west through Pennsylvania, to the central part of the state. From there it runs southward into Maryland and Virginia, being designated by other names beyond Pennsylvania. In the opposite direction, northward and northwestward in New York State, the formation becomes the Medina-Oneida conglomerate and sandstone.

CHARACTER AND RELATIONS

The Shawangunk formation is the oldest Silurian encountered in New Jersey and eastern Pennsylvania, where it forms the steep escarpment of Kittatinny Mountain through which run Delaware, Lehigh, Schuylkill, and Susquehanna rivers in their respective gaps. It is an indurated sandstone and conglomerate, the latter dominating and containing pebbles of white quartz usually about one-half an inch in diameter, although occasionally ones as much as an inch through are found. Small lenses of black shale an inch or two thick also occur. The sorting is fair to good, the sandy layers even-grained, and the conglomerate pebbles vary little in size in a given stratum. Some cross-bedding is present and also a few ripple marks; but channeling, mud cracks, and rain-drop impressions are unknown.

The stratigraphic relations of the Shawangunk formation are simple. It directly overlies, though unconformably, the Martinsburg shale, of late Middle to early Upper Ordovician age. It is overlain by the High Falls shale (except where that formation has been eroded), into which it appears to grade with no sharp transition. The High Falls shale is probably Clinton in age, being the eastward equivalent of the Clinton iron ore.

AGE OF THE SHAWANGUNK

Much has been written as to the age of the Shawangunk conglomerate. Beds of Lower Silurian age, and presumably of equivalent stratigraphic position, have been called in Eastern North America variously: Medina-Oneida, Shawangunk, Tuscarora, and Clinch. From all of these *Arthrophycus allegheniensis* Harlan (in

some of the older reports called *Arthrophycus harlani*) has been reported. This fossil is now generally accepted as an excellent guide to the Lower Silurian. Among the older geologists, Mather, Vanuxem, Jewett, Rogers, Lesley, and Cook, although they did not know of this fossil, the Shawangunk was unhesitatingly correlated with the basal Silurian of New York State, the Medina-Oneida. Recent opinions have in some measure followed, but often disagreed with, the older view. The recent tendency has been to place the Shawangunk higher up in the Silurian, calling it Salina in age. The reason seems largely to depend upon the interpretation of certain eurypterid remains that have come to light in the last two or three decades. These were first found at Otisville, New York, and later in Pennsylvania. A comparison of the various eurypterid faunas seems to point to an acceptance of the older rather than the newer view on the age of the formation.

Clarke and Ruedemann[1] give the following lists of Silurian eurypterids:

PITTSFORD SHALE

Hughmilleria socialis Sarle
Hughmilleria socialis robustus Sarle
Eurypterus pittsfordensis Sarle
Pterygotus monroensis Sarle
Stylonurus multispinosus Sarle

SHAWANGUNK CONGLOMERATE

Eurypterus maria Clarke
Eusarcus cicerops Clarke
Dolichopterus otisius Clarke
Dolichopterus stylonuroides Clarke and Ruedemann
Stylonurus (Ctenopterus) cestrotus Clarke
Stylonurus myops Clarke
Hughmilleria shawangunk Clarke
Pterygotus globiceps Clarke and Ruedemann

The correlation of the Shawangunk conglomerate with the Pittsford shale has been based upon a comparison of these two faunas. The species differ between the two, and the genera are not all the same. Moreover, the ranges of these genera are such that it seems unlikely that such a correlation is to be greatly relied upon. According to Clarke[2] they are:

Eurypterus	Ordovician through Permian
Stylonurus	Silurian through Pennsylvanian
Hughmilleria	Ordovician through Silurian
Pterygotus	Ordovician through Silurian
Dolichopterus	Silurian (also Ordovician)
Eusarcus	Ordovician through Silurian

These genera range for the most part from the Ordovician, at least through the Silurian, and even beyond that period. Moreover, it is interesting to compare the foregoing lists of species from the Pittsford and Shawangunk formations with those

[1] J. M. Clarke and R. Ruedemann, "The Eurypterida of New York," *Memoir 14, New York State Museum* (1912).

[2] J. M. Clarke, discussion of the Eurypterida in the Eastman-Zittel *Textbook of Paleontology*, Vol. 1 (1913) pp. 778–85.

reported as occurring in the Frankfort shale (Upper Ordovician): Clarke and Ruedemann[1] give the following:

FRANKFORT SHALE
Eurypterus megalops Clarke and Ruedemann
Eurypterus pristinus Clarke and Ruedemann
Eurypterus? (Dolichopterus?) stellatus Clarke and Ruedemann
Eusarcus longiceps Clarke and Ruedemann
Eusarcus triangulatus Clarke and Ruedemann
Dolichopterus frankfortensis Clarke and Ruedemann
Dolichopterus latifrons Clarke and Ruedemann
Hughmilleria magna Clarke and Ruedemann
Pterygotus prolificus Clarke and Ruedemann
Stylonurus? limbatus Clarke and Ruedemann
Pterygotus nasutus Clarke and Ruedemann

The Frankfort shale contains all the genera found in the Shawangunk conglomerate and Pittsford shale and two (*Eusarchus* and *Dolichopterus*) absent from the last-named formation. A closer faunal relation therefore appears to exist between the Shawangunk formation and the Frankfort than between the former and the Pittsford shale. The eurypterids of the Shawangunk are thus seen to be more nearly related to those of the Upper Ordovician than to those of the Upper Silurian. This paleontologic evidence points then to the Shawangunk being more probably Lower Silurian than Upper Silurian. Furthermore, the presence of *Arthrophycus* in the Shawangunk points to its being Lower Silurian, since that organism is conceded to be of that age.

ORIGIN OF THE SHAWANGUNK CONGLOMERATE

Following the deposition of the Martinsburg shale of Middle and early Upper Ordovician age, an elevation took place which lasted at least through the remainder of Ordovician time in the region of eastern Pennsylvania and New Jersey and southern New York. That no deposition went on until the beginning of the Silurian is inferred from the total absence of all Ordovician strata younger than the Martinsburg. During this long interval of uplift, there must have been considerable reduction of local topography as well as of the relief of Appalachia to the east. Under such conditions, débris accumulated on the flood plains of aggrading streams, while residual soils formed from weathering processes. That such accumulations did form is deduced from the character of the basal Silurian formations. These contain many quartz pebbles derivable from broken down crystalline rocks of the old land mass, while some of the basal Silurian is extremely "dirty" from residual materials of finer grain.

When Silurian time opened, the detritus-strewn surface was tilted westward, the axis running generally north-south not far east of the present Delaware River Valley. The evidence for this tilting is that deposition started again with the carrying westward of material to be laid down in the thick beds of the Shawangunk.

[1] Clarke and Ruedemann, *op. cit.*

During the Paleozoic, the Appalachian geosyncline was periodically receiving material from Appalachia. Through isostatic adjustment the geosyncline tended to sink and the land to rise, such a movement constituting the tilting believed to have occurred at the commencement of Silurian times. The resulting sedimentation was in the form of one or more deltas.

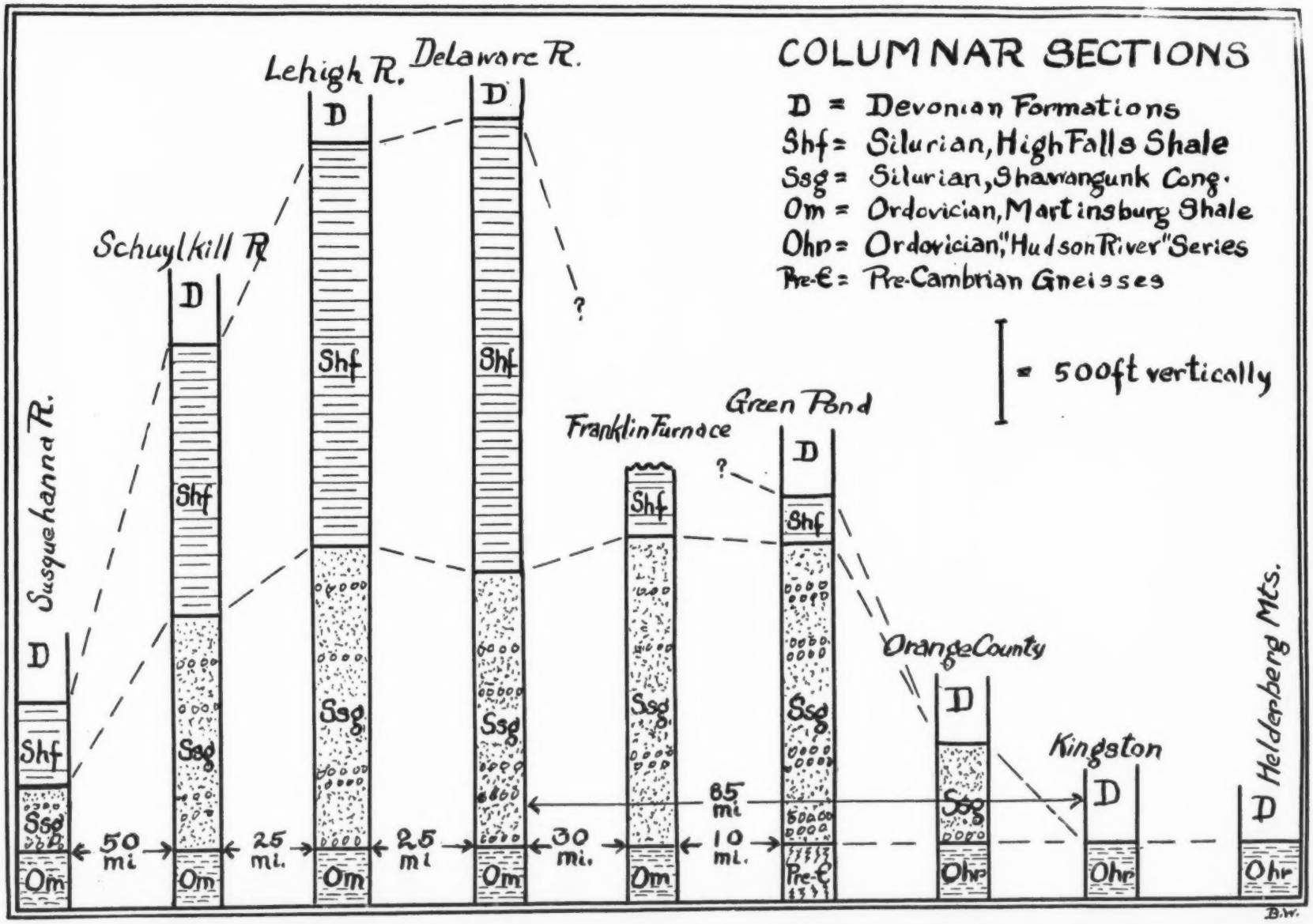
In northern New Jersey there is a formation called the Green Pond conglomerate. Its characters are those of the terrestrial phase of a delta, assuming the Shawangunk to be the seaward or submarine proportion. Although these subaerial and submarine equivalents are no longer continuous, it is believed that they are of the same age. The Green Pond conglomerate rests upon older formations than does the Shawangunk, as should be expected through onlap toward the source of supply. Lithologically, the Green Pond conglomerate has such subaerial characters as a red to purplish color; large, poorly sorted, subangular pebbles; and a muddy matrix. These characters are much more pronounced in the Green Pond than in the Shawangunk; and, moreover, there is a total lack, so far as known, of fossils in the former, while organic remains are known in the Shawangunk, a condition further in agreement with the supposed relations between the two formations.

But is the Shawangunk truly marine, granting the Green Pond to be nonmarine in origin? The change from reddish, non-marine beds in the Green Pond to the east to gray beds to the west away from the source of supply is indicative of a salt-water origin for the Shawangunk. Lack of channeling, fairly regular bedding, absence of mud cracks and rain-drop prints, and but few ripple marks substantiate this belief as to the origin of the Shawangunk, further emphasized by its rounder and better-sorted pebbles and cleaner matrix than the Green Pond. Paleontogically, too, the evidence is positive that the Shawangunk formed in the ocean. Silurian eurypterids are well-known associates of salt-water crustaceans, brachiopods, and graptolites; while Arthrophycus is compared to the lobworms of English sandy beaches today.

Furthermore, besides its lithological and paleontological characteristics, the formation as a whole shows the deltaic habit of thinning away from the source of supply. It is absent at the Hudson River (plate 40) but appears as a bed 10 feet thick at High Falls in New York State. In Orange County in the same state it has attained a thickness of 500 feet. Columnar sections running through New York, New Jersey, and Pennsylvania show this thickening to a maximum near the Delaware River of between 1,500 and 1,600 feet. Thence it thins steadily westward. Since the region of the Delaware River is close to the area occupied by the Green Pond formation, this thinning is away from the source of supply, typical of a delta deposit.

Conclusions and Summary

It has been shown, first, that the Shawangunk conglomerate is more probably Lower Silurian than Salina (Upper Silurian) in age, thus agreeing with the views of the earlier students of the formation. Furthermore, it has been demonstrated how the Shawangunk may have originated as the marine equivalent of a delta of which the Green Pond formation constitutes the subaerial portion.


COLUMNAR SECTIONS
D = Devonian Formations
Shf = Silurian, High Falls Shale
Ssg = Silurian, Shawangunk Cong.
Om = Ordovician, Martinsburg Shale
Ohr = Ordovician, "Hudson River" Series
Pre-C = Pre-Cambrian Gneisses
= 500ft vertically
Susquehanna R.
Schuylkill R.
Lehigh R.
Delaware R.
Franklin Furnace
Green Pond
Orange County
Kingston
Helderberg Mts.
50 mi
25 mi.
25 mi
30 mi.
10 mi.
85 mi
B.W.

SILICOFLAGELLATA FROM THE CRETACEOUS OF CALIFORNIA[1]

G. DALLAS HANNA

The Silicoflagellata form a small but exceedingly interesting order or class of protozoan animals. They have siliceous skeletons of unique structure and are known with certainty only from the upper Cretaceous to the present time. A few species are found living, widely distributed, near the surface of the sea, where they form a minor portion of the plankton.

Originally they were thought to be diatoms by Ehrenberg,[2] who described the first ones from the Tertiary of Sicily. Haeckel[3] transferred them to the Radiolaria, following Müller;[4] but in 1891 Borgert[5] determined their true nature, and since then they have been considered by most writers to represent a separate order of Mastogophora. Lemmermann[6] in 1901 monographed the group which he raised to the rank of order, giving all species and references which were known to him. A search of the bibliographies has disclosed only brief notices of no special taxonomic importance since Lemmermann's paper. Possibly some data are buried in the literature pertaining to the Radiolaria, not all of which has been searched in this connection, but certainly nothing of importance is hidden in the reports on the Diatomaceae. The scant attention the group has received may be seen by consulting the *Zoölogical Record* where, year after year, the word "vacant" follows "Silicoflagellata."

The organisms do not deserve to be so ignored. For a number of years I have been mounting them as a side issue when studying deposits of fossil diatoms, and a very considerable collection has accumulated in the California Academy of Sciences. The observations made warrant the statement that the Silicoflagellata as a group furnish most trustworthy horizon-markers. In making this assertion I do not except the diatoms, Foraminifera, mollusks, ostracods, and Radiolaria; these are the groups which have been most exhaustively searched for markers, either by myself or my assistants through a period of years.

The features which make the silicoflagellates valuable as markers are: (1) they are usually common when they occur at all; (2) species are exceedingly limited as

[1] Published by permission of the director of the California Academy of Sciences and the chief geologist of the Associated Oil Company.

[2] Ehrenberg, *Abhandl. d. k. preuss. Akad. d. Wiss.* (Berlin), 1838, p. 128.

[3] Haeckel, *Rept. Voy. H. M. S. "Challenger," Zoöl.*, vol. 18 (1887), p. 1557; also in *Monographie der Radiolarien*, 1862, p. 271.

[4] Johannes Müller, *Monatsber. d. k. preuss. Akad. d. Wiss.* (Berlin), 1855, p. 676.

[5] Borgert, "Über die Dictyochiden insbesondere über *Distephanus speculum* sowie Studien an Phaeodarien," *Zeitschr. f. Wiss. Zoöl.*, vol. 51 (1891), [separate pp. 1–52, pl. 33].

[6] E. Lemmermann, "Silicoflagellatae," *Ber. deutsch. bot. Ges.*, vol. 19 (1901), pp. 247–71, pls. 10–11.

to number in any formation; (3) the species have a very short geological life in most cases; (4) being pelagic in habitat they have a very wide geographic distribution; (5) the total amount of literature on the group is infinitesmal compared to the others mentioned above; (6) species are so distinct that they can be readily identified, and intergradation does not appear to have been noticed. In short, these organisms are almost the paleontologist's ideal of marker-fossils.

In a little series of papers I hope to illustrate the fossils of this group found in Western North American sediments, and the present contribution may be considered the first of the series. If possible, they will be arranged geologically, in ascending order so far as they are known to exist.

The present collection was obtained from the Moreno shale of upper Cretaceous age in the Panoche Hills on the west side of the San Joaquin Valley, Fresno County, California. The locality is No. 1144 in the records of the California Academy of Sciences and is more fully described as follows:

Loc. 1144 (Calif. Acad. Sci.). A section made across diatom-bearing upper Cretaceous (Moreno) shales in the second creek north of "Hayes Station" shown on Anderson and Pack's map (*U. S. Geol. Surv. Bull. 603* [1915]), SW. $\frac{1}{4}$ of NE. $\frac{1}{4}$, Sec. 6, T. 15 S., R. 12 E., M. D. M., Panoche Hills, Fresno County, California; G. D. Hanna, Coll., June 11, 1927. The exposed strata dip east about 35° and have about 75 to 150 feet of shales between them and the top of the Cretaceous (base of Eocene sandstone). The outcrop is in the second gulley on the south side of the small unnamed creek, as one passes up stream, and is very conspicuous as an extensive slope of scarcely weathered, white, platy shales. The shales above and below are characteristically brownish or purplish Moreno. The various samples collected are marked with the vertical distance below the top of the exposure. (The particular one from which the Silicoflagellata described herein came was 66 feet below the top and therefore 140 to 200 feet below the Cretaceous-Eocene contact.)

The type locality of the Moreno shale is in Moreno Gulch a few miles to the north of Loc. 1144, but the reader may be assured that the two stations are exact stratigraphic equivalents. A paper describing the diatoms found at the type locality has recently been published,[1] and the reason the silicoflagellates chosen for description were not those from that place is because the slides mounted from there were prepared with American styrax. While this substance is very superior to Canada balsam for siliceous organisms, it is far inferior to a synthetic resin noted as "A. F. S." and discovered after the Moreno Gulch material was prepared. Paleontologists may be certain that the forms described herein are found likewise at the type locality of the Moreno shale.

Three of the genera found seem to be undescribed. Haeckel[2] suspected that the ancestral form of the group would be found to be *Mesocena*, not *Dictyocha*, yet we find the latter and not the former in the Cretaceous.

It would be expected that these ancient forms would at least give a clue,

[1] G. D. Hanna, *Occ. Papers Calif. Acad. Sci.*, no. 13 (1927), pp. 1–48, pls. 1–5.

[2] Haeckel, *op. cit.*, p. 1558.

enough to warrant speculation, as to the origin of the organisms; and I believe that *Vallacerta hortoni* does offer such a suggestion. The markings on the pentagonal disk of this form are essentially the same as in some early forms of diatoms, such as Liradiscus and some Pyxilla. That the Diatomaceae and Silicoflagellata are genetically related seems to be assured, but which is the older remains to be determined. There is very little data thus far to connect either group with the Radiolaria.

Genus CORBISEMA Hanna, n. gen.

A triangular, hyaline, central cell joined to an outer, roundly triangular border with three straight bars of silica. Genotype: *Corbisema geometrica*, new species.

CORBISEMA GEOMETRICA Hanna, n sp.

Plate 41, figs. 1, 2

A small triangular, glassy, hyaline central space bounded by dense bars of silica is joined to an outer and also triangular border by straight bars; the outer border thus incloses three roundly triangular openings much larger than the central space; the point of junction between the supporting bars of the central cell and the outer border is indented, but no spine is found there; corners of outer border, rounded. Length of one side of specimen No. 3053 (fig. 2), 0.0760 mm.; specimen No. 3054 (fig. 1), 0.0864 mm.

Syntypes (Calif. Acad. Sci., Nos. 3053 and 3054) from Loc. 1144, Moreno shale, Fresno County, California; upper Cretaceous.

The normal form of the species is shown in figure 2; among hundreds of individuals examined, the only one seen which deviated from this is the one shown in figure 1; this is obviously merely a freak in lacking the central triangular space. The species is very common in the Moreno formation and does not fall within any known group of generic rank. It comes nearest to what Lemmermann[1] called *Dictyocha triacantha inermis* from the "cementstein" of Jutland; that form lacks the central hyaline space and has a spine at each junction point of supporting bar with outer margin. One form may be a development from the other, but they do not appear closely related.

DICTYOCHA QUADRALTA Hanna, n. sp.

Plate 41, fig. 3

Quadrangular, almost square, with concave sides and a heavy spine at each corner; from the center of all four sides bars project inwardly and upwardly (out of the plane of the basal spine-bearing square); those from two adjacent sides join, and the two pairs are united by a short diagonal bar; thus there are four spaces in the inclosed square, two triangular and two roughly quadrangular with one very short side; the basal square has linear markings on the bars of silica. Length of one side, exclusive of spines, .0652 mm.

Holotype (Calif. Acad. Sci. No. 3055) from Loc. 1144, Moreno shale, Fresno County, California; upper Cretaceous.

[1] E. Lemmermann, *Ber. d. deutsch. bot. Ges.*, vol. 19 (1901), p. 259, pl. 10, fig. 21.

The species is very common at the type locality and wherever siliceous fossils have been found in the Moreno formation. It is obviously related to such *Dictyocha* as *fibula*, but the relationship does not appear to be close.

Genus LYRAMULA Hanna, n. gen.

A simple bar of silica, either smooth or more or less scalariform, bent into a U or Y shape. Genotype: *Lyramula furcula*, new species.

LYRAMULA FURCULA Hanna, n. sp.

Plate 41, figs. 4, 5

A simple Y-shaped, hollow bar of silica with all three terminations sharply pointed, the stalk of the Y being the shortest. Distance from basal tip of Y to outer tips, specimen No. 3057 (fig. 4), 0.1120 mm.; specimen No. 3058 (fig. 5), 0.0964 mm.

Syntypes (Calif. Acad. Sci., Nos. 3057 and 3058) from Loc. 1144, Moreno shale, Fresno County, California; upper Cretaceous.

The hollow bar of silica is supposed to be a characteristic feature of the Silicoflagellata and is very obvious in this and the following species. Both are very common in the upper Cretaceous sediments wherever these have been found to contain siliceous fossils. Variation in *furcula* is confined to minor details of length and curvature of the three portions of the skeleton.

LYRAMULA SIMPLEX Hanna, n. sp.

Plate 41, fig. 6

A simple U-shaped bar of hollow silica, the terminations being incurved and blunter than in the preceding species; the surface of the bar is more or less scalariform and pitted on the outside. Distance from base of U to extreme tips, 0.0932 mm.

Holotype (Calif. Acad. Sci., No. 3056) from Loc. 1144, Moreno shale, Fresno County, California; upper Cretaceous.

The species is very distinct from *furcula* but equally common in the upper Cretaceous siliceous shales.

Genus VALLACERTA Hanna, n. gen.

A convex, sculptured, pentagonal disk with a heavy siliceous spine at each corner. Genotype: *Vallacerta hortoni*, new species.

VALLACERTA HORTONI Hanna, n. sp.

Plate 41, figs. 7–11

Disk almost a perfect pentagon, bordered with heavy silica, and very convex in cross-section; at each corner there is a heavy spine; usually these are equal in length, but this feature is subject to some variation; the sculpture consists of fine beads and pits, densely arranged and in no regular order. Extreme distance between points of spines of specimen No. 3059 (figs. 7, 8), 0.0752 mm.; diameter of disk of same specimen. .0384 mm.

Syntypes (Calif. Acad. Sci., Nos. 3059–62) from Loc. 1144, Moreno shale, Fresno County, California; upper Cretaceous.

This strange species is very common in the upper Cretaceous siliceous shales and has no close relative that I have been able to find in the literature of the Silicoflagellata. About all the variation that has been noted is shown in the four specimens illustrated. The sculpture on the disk is strongly suggestive of that found on certain low forms of diatoms, and this leads to the belief that here may be a form that is one of the connecting links between the two groups of organisms. The structure otherwise obviously allies it with the Silicoflagellata rather than with the Diatomaceae. In one variant seen, one side of the pentagon was greatly shortened, causing two spines to be very close.

The species is named for Mr. Harold M. Horton who has assisted me on numerous occasions, particularly in early exploration work on the Cretaceous shales.

EXPLANATION OF PLATE 41

FIG. 1.—*Corbisema geometrica* Hanna, n. sp. Syntype, No. 3054 (Calif. Acad. Sci.); ×550; a freak specimen lacking central hyaline space.

2.—*Corbisema geometrica* Hanna, n. sp. Syntype, No. 3053 (Calif. Acad. Sci.); ×525; the normal form of the species.

3.—*Dictyocha quadralta* Hanna, n. sp. Holotype, No. 3055 (Calif. Acad. Sci.); ×460.

4.—*Lyramula furcula* Hanna, n. sp. Syntype, No. 3057 (Calif. Acad. Sci.); ×375.

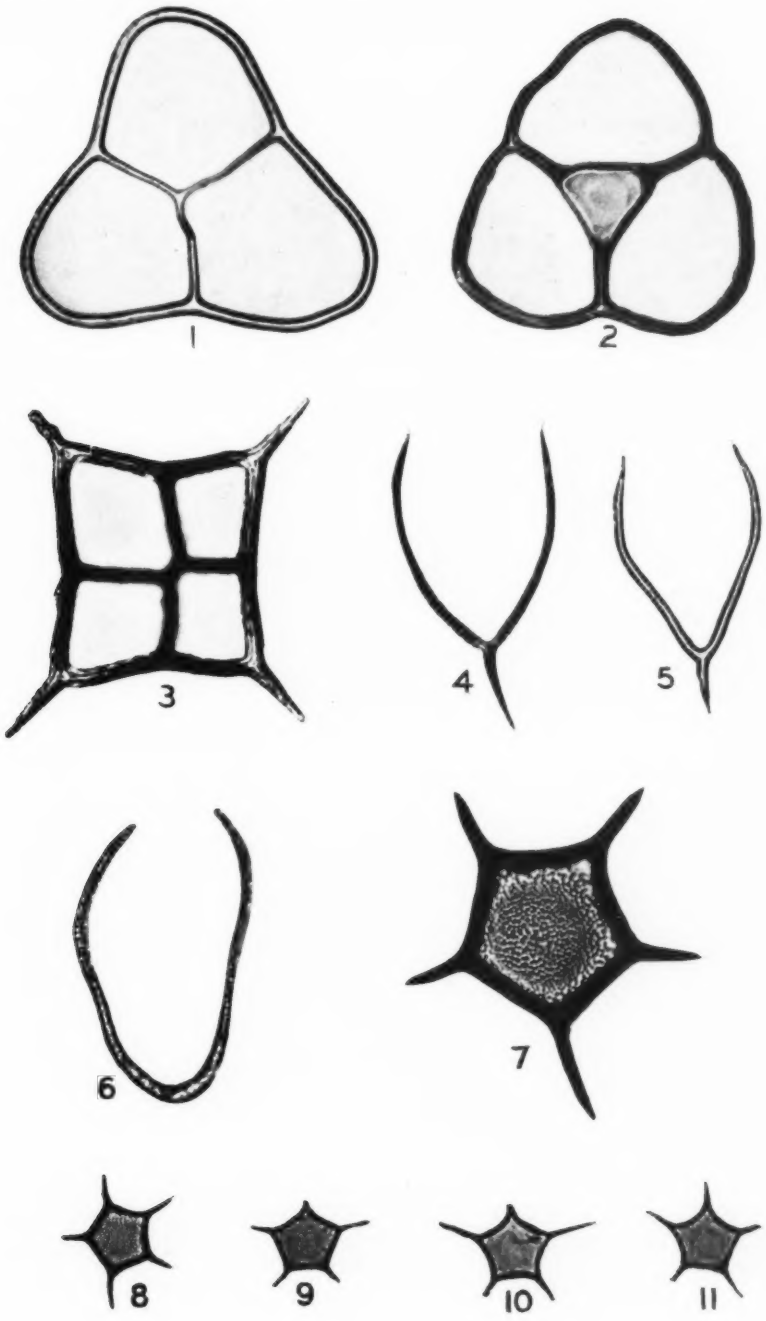
5.—*Lyramula furcula* Hanna, n. sp. Syntype, No. 3058 (Calif. Acad. Sci.); ×375.

6.—*Lyramula simplex* Hanna, n. sp. Holotype, No. 3056 (Calif. Acad. Sci); ×430.

7.—*Vallacerta hortoni* Hanna, n. sp. Syntype, No. 3059 (Calif. Acad. Sci.); ×600.

8–11.—*Vallacerta hortoni* Hanna, n. sp. Syntypes, Nos. 3059–62 (Calif. Acad. Sci.); ×240.

All of the specimens figured on this plate are from Loc. 1144 (Calif. Acad. Sci.), upper Cretaceous, Moreno shale from Panoche Hills, Fresno County, California; SW. ¼ of NE. ¼, Sec. 6, T. 15 S.; R. 12 E., M. D. M. The photographs were made by the author.


1
2
3
4
5
6
7
8
9
10
11

A NEW SPECIES OF *BOLIVINITA* FROM THE LOWER PLIOCENE OF CALIFORNIA

C. C. CHURCH
Associated Oil Company, San Francisco, California

INTRODUCTION

The Lower Pliocene of the Los Angeles Basin has been found to be rich in its variety and diversity of Foraminifera. Many new forms have been described and figured; but, due largely to a lack of time on the part of workers in this field, there still remain many interesting species that are new and undescribed.

The sample from which the species noted in this paper was obtained is from the Petroleum Securities Company's well, Mills No. 1, South Huntington Beach, Sec. 13, T. 6 S., R. 11 W.; depth, 2,820 feet.

The genus *Bolivinita* was erected by Dr. J. A. Cushman, in 1927, to contain the somewhat questionable form known as *Textularia quadrilatera* Schwager and *Bolivina quadrilatera* Wright.

No attempt at a complete synonymy is made, as it is not thought necessary in a paper of this kind.

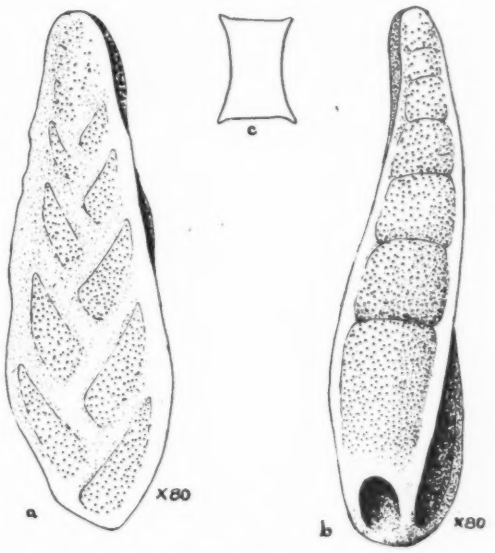


FIG. 1.—*Bolivinita angelina*, n. sp., ×80; *a*, holotype No. 2889 (Calif. Acad. Sci.), length 0.88 mm., width 0.31 mm.; *b*, paratype No. 2890, edge view, length 0.91 mm., thickness 0.21 mm.; *c*, paratype, No. 2891, diagrammatic cross-section.

DESCRIPTION OF SPECIES

BOLIVINITA ANGELINA, n. sp.

Description.—Test elongate, slightly twisted, compressed, quadrilateral, tapering to a rounded initial end; the broader faces strongly concave, the sides to a lesser degree; angles prominent, forming distinct carina; width about one-third that of length; chambers seven on each side, on the broader faces compressed below the suture lines, slightly convex on the edges; sutures broad, prominent and slightly raised above chamber faces, composed of clear shell material, practically straight, forming distinct angles: wall calcareous, hyaline, heavy and finely perforate: aperture oval and simple, at the inner margin of last-formed chamber.

Length of type specimen, 0.88 mm.; width, 0.31 mm.

Holotype.—California Academy of Science Coll., No. 2889.

Occurrence.—Common in the present sample but of rare occurrence elsewhere in the section, so that it may have a very narrow vertical range. Specimens are uniform in size, with very few longer than 1 mm. Their strong tests insure good preservation of the species. Closely related to *B. quadrilatera.*

BOLIVINA SINUATA Galloway and Wissler

Bolivina sinuata GALLOWAY and WISSLER, Jour. Paleon., vol. 1, July, 1927, p. 71, pl. 11, fig. 9.

The present form differs slightly from the Pleistocene species in being shorter, with more rounded sides and edges. The costae also appear to be more prominent and continuous near the initial end.

It is not common in this sample.

BULIMINA INFLATA Seguenza

Bulimina inflata SEGUENZA, H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 406, pl. 51, figs. 10–13.

This species occurs in some abundance here and is well preserved.

CASSIDULINA LOMITENSIS, var. ELEGANTULA Galloway and Wissler

Cassidulina lomitensis elegantula, GALLOWAY and WISSLER, Jour. Paleon., vol. 1, July, 1927, p. 79, pl. 12, fig. 9 *a*, *b*.

A large smooth species quite common and well preserved.

CASSIDULINA TRANSLUCENS Cushman and Hughes

Cassidulina translucens CUSHMAN and HUGHES, Contrib. Cushman Lab. Foram. Res., vol. 1, 1925, p. 15, pl. 2, figs. 5 *a–c*.

Not abundant here, but common in certain parts of the Lower Pliocene.

CIBICIDES MCKANNAI Galloway and Wissler

Cibicides mckannai GALLOWAY and WISSLER, Jour. Paleon., vol. 1, July, 1927, p. 65, pl. 10, figs. 5, 6.

This little form appears to range throughout most of the Pliocene and even up into the Pleistocene. It is very constant in its characters and fairly well preserved.

CIBICIDES WUELLERSTORFI (Schwager)

Anomalina wuellerstorfi SCHWAGER, *Novara*-Exped., geol., Theil., vol. 2, 1866, p. 258, pl. 7, figs. 105–7.

Truncatulina wuellerstorfi SCHWAGER, H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 662, pl. 93, figs. 8, 9.

The present form is referred to this species with some doubt as it seems to be somewhat more flattened, and attains a greater width. It is very common and has a fairly wide vertical range.

EPISTOMINA BRADYI Galloway and Wissler

Epistomina bradyi GALLOWAY and WISSLER, Jour. Paleon., vol. 1, July, 1927, p. 60, pl. 10, fig. 1.

This is a common form in the Lower Pliocene of the Los Angeles Basin, and in some places it attains a great size. It varies greatly in size, even in the same sample.

GLANDULINA OCCIDENTALIS Cushman

Nodosaria (*Glandulina*) *laevigata*, PARKER and JONES, Philos. Trans., vol. 155, 1865, p. 340, pl. 13, fig. 1.

Nodosaria (*Glandulina*) *laevigata* D'ORBIGNY, var. *occidentalis* CUSHMAN, U. S. Nat. Mus. Bull. 104, p. 4, 1923, p. 64, pl. 12, fig. 8.

A common species here, and quite variable in its shape and character.

GLOBIGERINA BULLOIDES d'Orbigny

Globigerina bulloides D'ORBIGNY, H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 593, pl. 77; pl. 79, figs. 3–7.

A common and widespread species, fossil and living.

GYROIDINA SOLDANII d'Orbigny

Rotalia (*Gyroidina*) *soldanii* D'ORBIGNY, Ann. Sci., Nat. vol. 7, no. 5, 1826, p. 278, *Modèles*, no. 36.

Rotalia soldanii D'ORBIGNY, CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 5, 1915, p. 71, pl. 29, fig. 1.

A common and well-preserved form here, but varying somewhat in size in other parts of the Lower Pliocene.

NODOGENERINA ANTILLEA (Cushman)

Sagrina virgula H. B. BRADY (part), Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 583, pl. 76, figs. 9, 10 (?).

Nodosaria antillea CUSHMAN, U. S. Nat. Mus. Bull. 104, pt. 4, 1923, p. 91, pl. 14, fig. 9.

This is a very small and delicate form. Only one was found.

NODOSARIA SOLUTA (Reuss)

Dentalina soluta REUSS, Zeitschr. deutsch. geol. Ges., vol. 3, 1851, p. 60, pl. 3, figs. 4 *a*, *b*.

Nodosaria soluta (RUESS), CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 3, 1913, p. 53, pl. 26, figs. 9–11.

The form as here represented has four chambers, and the sutures are less constricted than the form represented by Cushman's figures.

It is not common here.

NONION UMBILICATULA (Montagu)

Nonionina umbilicatula (MONTAGU) H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 726, pl. 109, figs. 8, 9.

This form is found all through the Pliocene and is living in the present oceans. It is never very abundant as a fossil.

ORBULINA UNIVERSA d'Orbigny

Orbulina universa D'ORBIGNY, H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 608, pl. 78; pl. 81, figs. 8–26; pl. 82, figs. 1–3.

A common form in this part of the Lower Pliocene.

PLECTOFRONDICULARIA CALIFORNICA Cushman and Stewart

Plectofrondicularia californica CUSHMAN and STEWART, Contrib. Cushman Lab. Foram. Res., vol. 2, 1926, p. 39, pl. 6, figs. 9–11.

This form is quite common in part of the Lower Pliocene section but is rarely, if ever, found complete in well cores. However, good specimens, complete in every way, are found in abundance in the Lower Pliocene shales outcropping in the Palos Verdes Hills.

PLECTOFRONDICULARIA, sp.?

This is a very large form measuring over 4 mm. in length in some cases but quite similar in shape and markings to the smaller form described above. Their similarity, with the fact that they are so commonly found together, suggests a very close relationship.

PULLENIA SPHAEROIDES (d'Orbigny)

Nonionina sphaeroides D'ORBIGNY, Ann. Sci. Nat., vol. 7, no. 1, 1826, p. 293, *Modèles*, no. 43.
Pullenia sphaeroides (D'ORBIGNY), CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 4, 1914, p. 20, pl. 11, fig. 2.

Occurs very sparingly in the Lower Pliocene of California.

ROBULUS RENIFORMIS (d'Orbigny)

Cristellaria reniformis D'ORBIGNY, CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 3, 1913, p. 65, pl. 30, fig. 4.

The fossil representative of this species as found here is much smaller than the living form. It is not over 0.5 mm. in width. Not common.

UVIGERINA PEREGRINA Cushman

Uvigerina peregrina CUSHMAN, U. S. Nat. Mus. Bull. 104, pt. 4, 1923, p. 166, pl. 42, figs. 7–10.

Not common, and rather poorly preserved here.

UVIGERINA AUBERIANA d'Orbigny

Uvigerina auberiana D'ORBIGNY, CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 3, 1913, p. 102, pl. 37, fig. 5.

A common and widely distributed species.

A NEW NONION FROM PERU

E. Willard Berry

The West Coast of South America which stretches from about Lat. 10° N. to about 55° S. is little known biologically, except for the memorable voyage of d'Orbigny in 1839 and a recent voyage by Beebe this past year.

Puerto Pizarro, the port of Tumbez of historic note, is situated at the mouth of the Tumbez River in about Lat. 3°40′ S. and Long. 81°30′ W. of Greenwich.

The Rio Tumbez is the river on the north of the West Coast desert, and there is desert for about 100 miles to the south to the Rio Chira.

I was fortunate enough to get several ounces of mud from about 8 fathoms in the harbor at Puerto Pizarro. This mud was relatively free from organic life. There were about 20 specimens of Foraminifera, all but one of a single species; two fragments of *Dentalium;* and one ostracod. Of the Foraminifera, one species was so badly broken as to be indeterminable except as to probably the genus—*Discorbis*. The other species is apparently a new species of *Nonion* and may be described as follows:

NONION PIZARRENSIS Berry, n. sp.

Figs. 1–3

Test not quite bilaterally symmetrical, there being a slight dropping of the apertural angle on the left side of the apertural face, umbilici depressed; chambers numerous, usually twelve in the last-formed volution; sutures not very distinct, only slightly depressed, at the periphery flush, aperture a very narrow curved opening at the base of the apertural wall of the last chamber; wall smooth, polished.

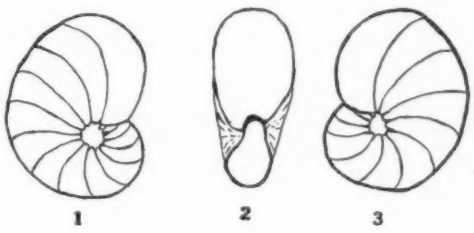


Fig. 1

Diameter, longest about 0.63 mm., shortest 0.46 mm. Ratio of thickness to diameter is 1:3.

N. pizarrensis appears quite like *N. boueana* d'Orbigny described by Flint from the Gulf of Tokyo in 9 fathoms. *N. pizarrensis* has a smooth not granular surface and is not quite bilaterally symmetrical.

The type is from about 8 fathoms of water at the mouth of the Tumbez River at Puerto Pizarro, Peru.

N. pizarrensis is the most common small form from this place. The species is named from the locality.

One other species of Foraminifera was found with it; but as I have only one specimen, and that broken, I cannot say more than that it appears to be a *Discorbis* sp.

A GROUP OF FORAMINIFERA FROM THE CANYON DIVISION OF THE PENNSYLVANIAN FORMATION IN TEXAS

JAMES A. WATERS
Dallas, Texas

The shales from which this fauna was collected are exposed below the Ranger limestone 5.4 miles southwest of Brownwood, Texas, on the Trickham road. The few feet of alternating sandy and slightly calcareous shales, though considerably weathered, yield a great number of good specimens. The variety of species is not great, but the abundance and state of preservation of the micro-fossils are remarkable.

The fauna is represented by truly arenaceous specimens and forms described as arenaceous but whose tests are composed of calcareous grains cemented with a cement of the same composition. The cement used by the Foraminifera which built their tests of sand or silica is of non-calcareous composition.

Inasmuch as both types of arenaceous Foraminifera are found in this 6-foot thickness of shale, it is fairly certain that two classes of sediments were represented, namely, calcareous and sandy shales.

The morphology of the tests of the Paleozoic Foraminifera studied has reflected the nature of the sediments in which they lived. In calcareous shales or limestones, the tests of the micro-fossils are made up of calcareous grains with a similar cement. In sandy shales, the micro-fauna consists of truly arenaceous species with siliceous cement. Thus far, in the study of the Paleozoic forms, the calcareous and truly arenaceous Foraminifera have not been present in the same type of sediments. This would lead us to believe that the calcareous forms built their tests of calcareous grains and were not able to secrete sufficient calcareous cement to construct the entire tests of cement alone. No truly arenaceous forms studied have substituted calcareous cement for siliceous in making their test. It appears reasonable that these primitive forms would use the most available material in constructing their tests.

The facts derived from a study of the Paleozoic faunas substantiate this hypothesis. If the Foraminifera of the Paleozoic formations had been able to build tests of a material secreted from the sea water, as did those in the younger formations, the type of sediments would not have had so much influence on the nature of the test.

Some genera occur in both sandy and calcareous sediments. For example, the genus *Ammobaculites*, when present in limestones or calcareous shales, has a fairly large, smooth, calcareous test; but when found in sandy shale, the test is very small and composed of quartz grains.

One can easily imagine conditions which would give rise to a mixture of sediments and which might yield micro-fossils having tests of varying compositions. Many of the more recent species of Foraminifera are selective in building their tests. Whether the Paleozoic forms are as selective I do not know. It would be very interesting, for example, to determine whether the genus *Ammobaculites* preferred to use quartz or calcareous grains in making its test, or lazily accepted whatever nature provided.

This can be determined by a study of the lithology of the beds from which faunas are taken. It may be that the selective ability of Foraminifera was not developed until more uniform marine conditions existed. It seems that in the sediments the predominating material which was suitable for building influenced the micro-fossils in selecting fragments for their tests. The study of the morphology of the tests can be carried to the cementing material, the texture of the fragments, and their influence on the physical structure. It seems strange that the quartz grains in the tests are not sometimes cemented with calcareous material. Considering the relative solubility of the lime and silica, it would seem easier for the organisms to obtain a lime cement than a siliceous cement from the water.

These are a few of the observations made and the questions which arose while comparing other Pennsylvanian faunas with groups of micro-fossils from the Canyon formation.

Textularia fuscalignensis Cushman and Waters, *Bradyina holdenvillensis* Harlton, and *Nodosinella glabra* Cushman and Waters are present in this group but have not been figured, having been shown in previous publications. The remainder of the group is figured on plate 42 with descriptions and measurements.

Family HYPERAMMINIDAE

Genus HYPERAMMINA Brady, 1878

HYPERAMMINA CLAVATA Waters, n. sp.

Plate 42, figs. 9 *a*, *b*

Test long, slender, club shaped; usually somewhat compressed with small proloculum and larger second chamber, narrowest above proloculum, increasing in diameter toward the terminal end, which is closed except for aperture; wall smoothly arenaceous, siliceous material with much cement; aperture small, oval, central, and terminal; color, white.

Length of holotype, 2.21 mm.; diameter of proloculum, 0.26 mm.; diameter at apertural end, 0.63 mm.

Family AMMODISCIDAE

Genus AMMODISCUS Reuss, 1861

AMMODISCUS INCERTUS? d'Orbigny

Plate 42, fig. 1

Test small, planispiral, consisting of proloculum and coiled tube, somewhat constricted; early coils increasing uniformly in diameter, final coil unusually large

in diameter; five or six coils in all; wall finely arenaceous, calcareous material with much cement; aperture formed by open end of tube; color, white.

Diameter of test, 0.90 mm. Diameter of tube at aperture, 0.16 mm.

Genus GLOMOSPIRA Rzehak, 1888

GLOMOSPIRA COMPRESSA Waters, n. sp.

Plate 42, fig. 5

Test large, fairly rough, compressed; consisting of a proloculum and second chamber, which is a flatly oval tube, irregularly coiled; wall arenaceous with siliceous fragments and little siliceous cement; aperture an oval opening at the end of the tubular chamber; color, grey.

Diameter of holotype, 1.10 mm.×1.32 mm.; breadth of tube at terminal end, 0.37 mm.

Genus LITUOTUBA Rhumbler, 1895

LITUOTUBA CALCARINA Waters, n. sp.

Plate 42, figs. 2, 3

Test small, smooth, approximately planispiral in early portion of coil, consisting of a proloculum, and a coiled tube which becomes straight in its final stages; coils number four or five, partially overlapping; wall very finely arenaceous, of calcareous material with much calcareous cement; aperture circular, opening at the end of tubular chamber; color, white.

Diameter of test, 0.53 mm.; diameter of tube at aperture, 0.15 mm.

Family LITUOLIDAE

Genus ENDOTHYRA Phillips, 1846

ENDOTHYRA MEDIA Waters, n. sp.

Plate 42, fig. 12

Test rather large, smooth, slightly involute; chambers distinct, numbering ten in last-formed coil; edge rounded; sutures slightly depressed; wall smoothly arenaceous, calcareous grains with considerable calcareous cement; aperture a rather high arch at the inner margin of the final chamber; color, white.

Diameter of holotype, 1.00 mm.—1.16 mm.; diameter of outer coil, 0.42 mm.; diameter of inner coil, 0.37 mm.; maximum thickness, 0.32 mm.

ENDOTHYRA GRANDIS Waters, n. sp.

Plate 42, figs. 13, 14

Test large, smooth, somewhat involute, coils and chambers distinct, edge rounded, periphery limbate; breadth of last-formed coil uniform; eleven chambers in final coil; sutures well depressed; wall smoothly arenaceous, calcareous particles with much cement; aperture large, a very high arch on the inner margin of the final chamber; color, white.

Diameter of holotype, 1.53 mm.—1.68 mm.; diameter of last coil, 0.42 mm. and 0.37 mm.; maximum thickness, 0.50 mm.; thickness of first chamber of final coil, 0.42 mm.

ENDOTHYRA OVATA Waters, n. sp.

Plate 42, fig. 6

Test small, smooth, oval, slightly umbilicate, somewhat involute; coil increasing rapidly in breadth, edge rounded; chambers distinct, numbering eight in the last-formed coil; sutures very slightly depressed; wall smoothly arenaceous, calcareous particles with much calcareous cement; aperture a high arch at the inner margin of the final chamber; color, white.

Diameter of test, 0.84 mm.—0.63 mm.; diameter of coil, 0.37 mm. and 0.21 mm.; maximum thickness, 0.32 mm.

Genus AMMOBACULITES Cushman, 1910

AMMOBACULITES NITIDA Waters, n. sp.

Plate 42, fig. 15

Test small, rough, with early portion coiled, later portion uncoiled in rectilinear series; five chambers in coiled, and five chambers in uncoiled portion; sutures moderately depressed; wall roughly arenaceous, sand grains with little siliceous cement; aperture circular, central, and terminal; color, grey or brown.

Length of holotype, 1.00 mm.; diameter of coil, 0.32 mm.; diameter of uncoiled portion, 0.26 mm.

This species differs from *Ammobaculites minuta* and *gracilis* in the greater diameter of the linear portion of its test.

AMMOBACULITES GRACILIS Waters, n. sp.

Plate 42, figs. 4 *a*, *b*

Test minute, slender, slightly rough, tapering from final to initial chamber, planispiral in early portion, five chambers in number; later portion numbering six chambers, uncoiled in linear arrangement; wall arenaceous, fine sand with siliceous cement; sutures well depressed; aperture circular, central and terminal, color, white.

Length, 0.90 mm.; diameter of final chamber, 0.21 mm.; diameter of coil, 0.26 mm.

This species differs from *Ammobaculites nitida*, in the diameter of the test and the increasing dimensions of the chambers toward the apertural end.

Family TROCHAMMINIDAE

Genus TROCHAMMINA Parker and Jones, 1860

TROCHAMMINA RUDIS Cushman and Waters (?)

Plate 42, fig. 8

Test fairly smooth, trochoid, high spired, consisting of seven or eight subglobular chambers, spirally coiled; sutures distinct; wall rather coarsely are-

naceous, siliceous particles and siliceous cement; aperture on ventral side; color, brown.

Diameter of holotype, 0.81 mm.; thickness, 0.63 mm.

Family TEXTULARIIDAE

Genus TEXTULARIA Defrance, 1824

TEXTULARIA CORNUTA Waters, n. sp.

Plate 42, fig. 7

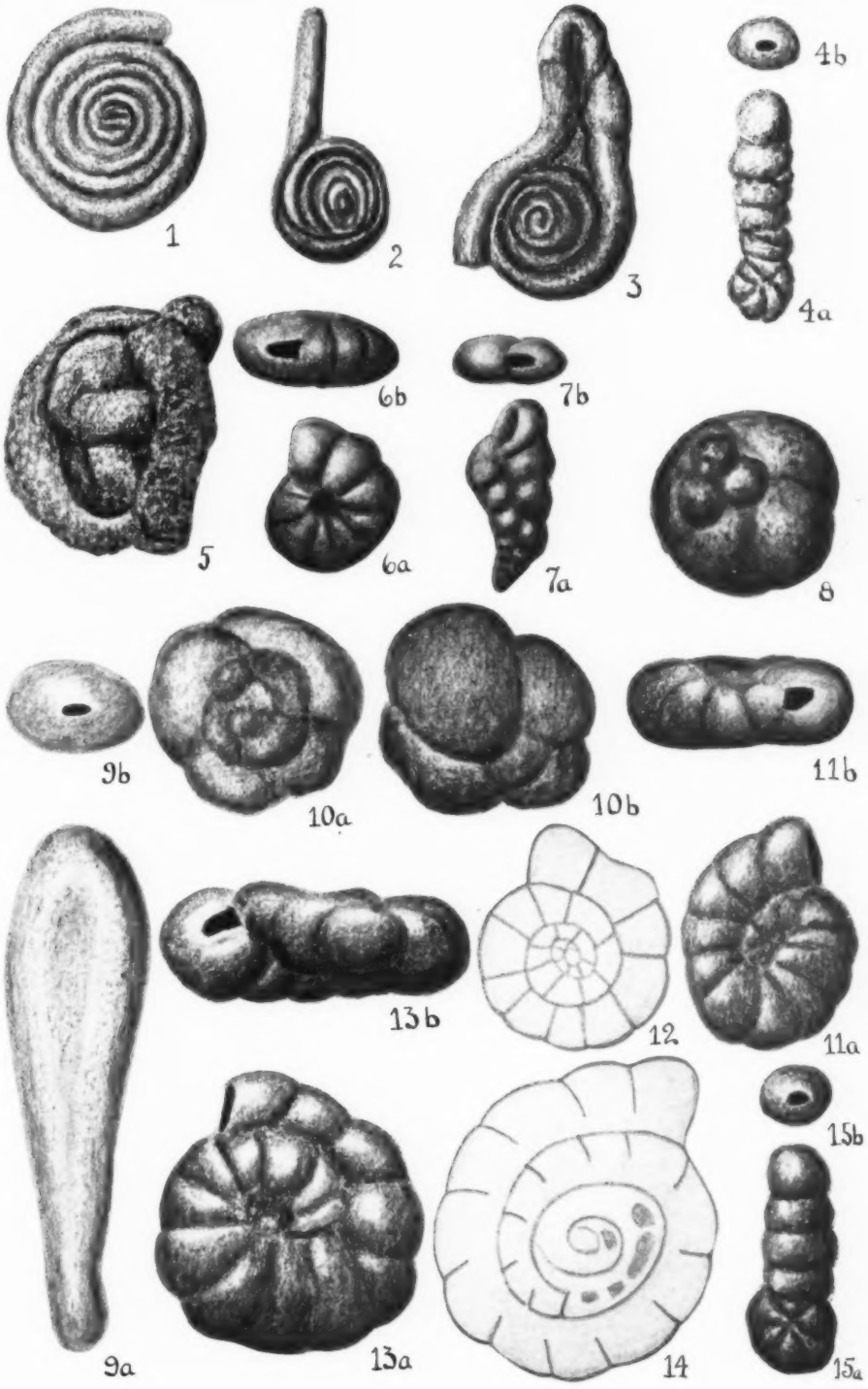
Test very small, somewhat rough, short, stout, composed of planispiral chambers in the early portion, biserial in later; sutures moderately depressed; edge rounded; wall coarsely arenaceous, fine sand with considerable cement; aperture, a high arch at base of final chamber; color, white.

Length of test, 0.84 mm.; greatest breadth, 0.47 mm.

This species is much smaller than any textularian form yet noted in the Carboniferous formation. The whole test is slightly spiraled about a longitudinal axis, as are many of the truly arenaceous Textulariidae.

EXPLANATION OF PLATE 42

FIG. 1.—*Ammodiscus incertus* d'Orbigny, ×70.
2.—*Lituotuba calcarina* Waters, n. sp., ×82.
3.—*Lituotuba calcarina* Waters, n. sp., ×82. Abnormal specimen.
4.—*Ammobaculites gracilis* Waters, n. sp., ×82. *a*, side view; *b*, apertural view.
5.—*Glomospira compressa* Waters, n. sp., ×60.
6.—*Endothyra ovata* Waters, n. sp., ×60. *a*, side view; *b*, apertural view.
7.—*Textularia cornuta* Waters, n. sp., ×75. *a*, side view; *b*, apertural view.
8.—*Trochammina rudis* Cushman and Waters, ×80.
9.—*Hyperammina (?) clavata* Waters, n. sp., ×82. *a*, side view; *b*, apertural view.
10.—*Trochammina arenosa* Cushman and Waters, ×90. *a*, dorsal view; *b*, ventral view.
11.—*Endothyra media* Waters, n. sp. *a*, side view, ×60; *b*, peripheral view, ×65.
12.—*Endothyra media* Waters, n. sp., ×68. Section.
13.—*Endothyra grandis* Waters, n. sp., ×60. *a*, side view; *b*, apertural view.
14.—*Endothyra grandis* Waters, n. sp., ×75. Section.
15.—*Ammobaculites nitida* Waters, n. sp., ×85. *a*, side view; *b*, apertural view.


1
2
3
4b
4a
5
6b
7b
6a
7a
8
9b
10a
10b
11b
9a
13b
12
11a
13a
14
15b
15a

SPECIES OF LARGE ARENACEOUS AND ORBITOIDAL FORAMINIFERA FROM THE TERTIARY DEPOSITS OF JAMAICA

THOMAS WAYLAND VAUGHAN
Scripps Institution of Oceanography, La Jolla, California

(Plates 43–50)

CONTENTS

Introduction

Stratigraphy of the Tertiary formation of Jamaica

Stratigraphic distribution of the larger Foraminifera
- Middle Eocene ("Yellow limestone")
- Upper Eocene
- Oligocene
  - Moneague formation
  - Montpelier white limestone
- Miocene

Systematic account of species
- Family Orbitolinidae
  - Genus *Dictyoconus*
    - *Dictyoconus codon* Woodring
      - *puilboreauensis* Woodring
  - Genus *Cushmania*
    - *Cushmania americana* (Cushman)
      - *fontabellensis* Vaughan, n. sp.
  - Genus *Lituonella*
    - *Lituonella*, sp.
- Family Orbitoididae
  - Genus *Miogypsina*
    - *Miogypsina bracuensis* Vaughan, n. sp.
  - Genus *Discocyclina*
    - *Discocyclina crassa* (Cushman)
      - sp., aff. *D. pustulata* (Cushman)
      - *perkinsi* Vaughan, n. sp.
  - Genus *Asterocyclina*
    - *Asterocyclina georgiana* (Cushman)
      - sp. indet.
  - Genus *Lepidocyclina*
    - Subgenus *Pliolepidina*
      - *Lepidocyclina (Pliolepidina) kinlossensis* Vaughan, n. sp.

Subgenus *Lepidocyclina*
Lepidocyclina (*Lepidocyclina*) *macdonaldi* Cushman
trinitatis H. Douvillé
sherwoodensis Vaughan, n. sp.
canellei Lem. and R. Douvillé
yurnagunensis Cushman
miraflorensis Vaughan
forresti Vaughan
parvula Cushman
matleyi Vaughan, n. sp.
Subgenus *Nephrolepidina*
Lepidocyclina (*Nephrolepidina*) *haddingtonensis* Vaughan, n. sp.
sp., cf. *L. perundosa* Cushman
undosa Cushman
gigas Cushman
gigas Cushman, var.
crassata Cushman
List of literature cited
Explanation of plates
Plates 43–50

Introduction

Dr. C. A. Matley, while working as government geologist of Jamaica from October, 1921, to April, 1924, made an extensive collection of rocks and matrix containing larger Foraminifera; and he paid me the compliment of submitting the material to me for examination and report. I first gave him a list of tentative determinations with indications of the horizons represented, and later described the species that appeared to be new and sent him a revised list; but, as I was still in doubt regarding some identifications and the validity of some of the supposedly new forms, I have delayed publication until I could make additional studies of the American species with which comparisons were needed.

Most of the material is rock from which individual specimens cannot be separated; and, therefore, it had to be studied in thin sections, some hundreds of which were cut in the petrographic laboratory of the United States Geological Survey. As an aid to studying the material a large number of micro-photographs, enlarged 20 times, were made by Mr. Ernest Shuster in the photographic laboratory of the Geological Survey.

The types of new species and a set of other specimens will be deposited in the United States National Museum; while a set of specimens will be returned to Dr. Matley, probably for deposit in the British Museum (Natural History); and some duplicates will be retained for the collection of the Scripps Institution.

The present paper treats of the groups indicated in its title. Accounts of other genera will be given in a subsequent article.

Stratigraphy of the Tertiary Formations of Jamaica

Dr. Matley's report on the geology of Jamaica has not yet been published, but he has given a brief statement regarding the different zones in an abstract of a paper by him, "Recent Geological Work in Jamaica," presented at the meeting of

the British Association for the Advancement of Science in Toronto in 1924. As I have no printed copy of the abstract the following statement is from a typewritten copy kindly sent to me by Dr. Matley:

An effort has been made to zone the Tertiary limestones by means of their foraminifera. The Yellow Limestone, recently proved by Trechmann to be of Middle Eocene age, contains beds full of *Operculina* with a few minute *Dictyoconi*, occasional beds of *Alveolina*, and others with a large *Orthophragmina*. The overlying White Limestone ranges from Upper Eocene to Upper Oligocene, the foraminiferal succession in ascending order being as follows: *Alveolina* and *Dictyoconus; Dictyoconus* with *Alveolina;* small lenticular Lepidocyclines; large Lepidocyclines (zone of *Lepidocyclina* cf *gigas* and *L. undosa*); *Sorites*. The *Sorites*-zone forms the Santa Cruz Mountains of St. Elizabeth and large tracts of Manchester. The flint-bearing, chalky, and globigerinal "Montpelier Formation" of Hill lies below the *Lepidocyclina undosa* zone, but its type of sedimentation is missing from the succession in many parts of the island and it seems to be a deep-water facies of the White Limestone that passes laterally into shallower-water mollusca-bearing beds. Hill's "Moneague Formation" certainly includes the *L. undosa* zone but its upper limit was not defined by that writer. Above the Moneague Formation he places his "Cobre Formation" as the highest division of the White Limestone, but his type section in the Cobre gorge contains an abundance of *Dictyoconus* and there is an absence of *Sorites*, which indicate that the strata lie below the *L. undosa* zone and the Moneague beds. The base of the White Limestone is of variable horizon, sometimes passing up conformably from the Yellow Limestone, sometimes overlapping on to older rocks against the shores of a subsiding land.

Dr. C. T. Trechmann has recently published a number of valuable papers on the Cretaceous and middle Eocene of Jamaica. Although these articles constitute important advances in knowledge of West Indian geology, they are not listed here, since they do not need to be discussed in the present connection.

Stratigraphic Distribution of the Larger Foraminifera

No Miocene species are described in this paper. Since for the older deposits the geologic horizon and the localities are stated under each species, all that is necessary here is to list the species according to their apparent stratigraphic position.

MIDDLE EOCENE ("YELLOW LIMESTONE")

Dictyoconus codon Woodring
Lituonella, sp.
Alveolina, spp. indet.

UPPER EOCENE

Dictyoconus puilboreauensis Woodring
Cushmania americana (Cushman)
fontabellensis Vaughan
Discocyclina crassa (Cushman)
sp. aff. *D. pustulata* (Cushman)
perkinsi Vaughan, n. sp.
Asterocyclina georgiana (Cushman)
sp. indet.
Lepidocyclina kinlossensis Vaughan
macdonaldi Cushman
trinitatis H. Douvillé
sherwoodensis Vaughan
haddingtonensis Vaughan
sp. cf. *L. perundosa* Cushman

OLIGOCENE

Moneague formation:
Lepidocyclina canellei Lem. and R. Douvillé
yurnagunensis Cushman
miraflorensis Vaughan
forresti Vaughan
parvula Cushman
matleyi Vaughan
undosa Cushman
gigas Cushman
gigas Cushman, var.
crassata Cushman
Montpelier white limestone:
Miogypsina bracuensis Vaughan
Lepidocyclina canellei Lemoine and R. Douvillé
undosa Cushman
crassata Cushman

It is stated in discussing the species found in the Montpelier white limestone that they represent a stratigraphic horizon of the Moneague formation and that the difference between that part of the Montpelier of which I examined specimens and the material from the Oligocene part of the Moneague is due rather to difference in lithology than to difference in age. The Oligocene may be susceptible to division into zones, which of course must be based on detailed field knowledge and should not be attempted in such an article as this.

MIOCENE

Although no Miocene species are described in this paper, it may be stated that the Miocene deposits contain many specimens of *Sorites*, *Archaias*, and probably *Peneroplis*. It is intended to give an account of the species of those genera in a subsequent paper.

Systematic Account of the Species

Family ORBITOLINIDAE

Genus DICTYOCONUS Blackenhorn[1]

DICTYOCONUS CODON Woodring

Plate 43, figs. 1–5 *b*

Woodring (**19**, p. 603), Vaughan (**13**, p. 254), Cushman (**5**, p. 198).

Certain specimens in the collections made in Jamaica by Dr. Matley appear to be virtually identical with specimens collected in Haiti. Both specimens with wide bases and narrow bases occur together in the same rock. Two such specimens are illustrated by plate 43, figures 1 and 2. Because of the similarity in structure, as is shown by the illustrations, it is my belief that both kinds of specimens belong to the same species and represent only variants; plate 43, figure 1, however, illustrates the typical form.

[1] For the benefit of those who may not have worked with figures of this group of Foraminifera, it will be said that the skeletal elements are dark and the interspaces light on the illustrations.

A variation of significance is that of the number and the degree of thickening of the minute, short lamellae that project from the lateral walls into the cavities between the successive skeletal floors. On the right-hand side of plate 43, figure 1, the number in each space is small, only one, two, or three; but on the left-hand side of the same figure they are more numerous, four being common, and, therefore, more crowded. In the specimen represented by plate 43, figure 2, they are as on the left side of figure 1. In figure 3, of the same plate, the number is somewhat larger, consequently with more crowding, and there is considerable anastomosis, especially near the summit of the specimen. The condition in this last-mentioned specimen is very near that represented in *Cushmania* (Silvestri, **12,** p. 52), which will be more fully discussed under species referred to that genus.

Geologic horizon and localities.—The middle Eocene "Yellow limestone" at numerous localities on the boundary of the parishes of St. Elizabeth and Manchester and in the Peace River district of the parish of Clarendon. The specimens figured are as follows: plate 43, figures 1, 2, and 3, J. 504 M., Spice Grove, and figures 4 *a* and 4 *b*, J. 505 M., Phantillands Parochial road, 1.8 miles from the main road; both localities on the boundary of the parishes of St. Elizabeth and Manchester; figures 5 *a* and 5 *b*, J. 605 M., Davyton road at $4\frac{7}{8}$ miles, Peace River district. The last specimens resemble *D. puilboreauensis* Woodring in form, but the reason for referring them to *D. codon* has already been stated. *D. codon* was originally described from the middle Eocene Plaisance limestone of Haiti and has been reported by me (1923) and Cushman (1927) from deep wells in Florida.

DICTYOCONUS PUILBOREAUENSIS Woodring

Plate 43, fig. 6

Woodring (**19,** p. 609).

At the time Woodring described this species he said: "There is a possibility that the 'two' species are megalospheric and microspheric forms of the same species." Although I have referred certain specimens of *D. puilboreauensis* shape to *D. codon*, I am applying the name *D. puilboreauensis* to some specimens, one of which is illustrated; but I share with Woodring his doubts as to their being "two" distinct species.

Geologic horizon and localities.—Eocene at several localities. The specimen figured is from J. 58 M., west of Borehole, Hyde, Trelawny, associated with *Discocyclina*, *Asterocyclina*, and Eocene species of *Lepidocyclina*. At this locality the horizon appears to be upper Eocene.

Genus CUSHMANIA Silvestri

CUSHMANIA AMERICANA (Cushman) Silvestri

Plate 44, figs. 1, 2

Conulites americana, Cushman (**3,** p. 43); *Cushmania americana*, Silvestri (**12,** p. 52).

Certain of the specimens collected by Dr. Matley agree too closely with the type-specimen of Cushman's species to receive a separate designation. Another

specimen in the same thin section as the two specimens here figured is almost identical with Cushman's type, except that it is 2 mm. tall while the type is about 1 mm. tall. Silvestri's description of the wall of his *Cushmania* is correct, but I doubt the validity of his proposed genus, for it appears to me that the mural features of *Dictyoconus* and *Cushmania* intergrade, as has been indicated in discussing *Dictyoconus codon*. Although I venture this suggestion, I hesitate to express positive disagreement with so profound a student of this group of organisms as Dr. Silvestri. This entire group of Foraminifera needs more investigation than it has yet received, notwithstanding the excellent work of Schlumberger, Silvestri, and H. Douvillé. Although the treatment in his paper is tentative, present stratigraphic needs are satisfied, and perhaps some advance is made in knowledge of certain structural features.

In this connection a diversion will be made to state that the species referred to *Orbitolina* from the Lower Cretaceous of Texas also need restudy. I have had several thin sections prepared of the Texas species. They belong to genera different from those of the Tertiary species (Vaughan, **13**, p. 254) and appear to represent at least two distinct genera. Cushman has just published additional information on the genera of some of the Florida Tertiary forms (Cushman, **5**), but the accounts are too vague. The activity here indicated constitutes a hopeful sign, and it may not be long before this complex and interesting group of fossil organisms will be adequately studied for America.

Geologic horizon and localities.—Eocene, J. 22 M., Fontabella, at River Rise, Trelawny.

CUSHMANIA FONTABELLENSIS Vaughan, n. sp.

Plate 44, fig. 3

Comparison of figures 1 and 3 on plate 44 will make evident the essential similarity in structure of *C. americana* and *C. fontabellensis*. The relation of the former to the latter is similar to that of *Dictyoconus puilboreauensis* to *D. codon*. There may in reality be only one species, but in the present stage of information different names are helpful.

The basal diameter of the holotype of *C. fontabellensis* is 9.65 mm., virtually 10 mm.; and the height is 3 mm. The upper surface is domed, and the central part of the lower surface is slightly concave upward. The outer part of the base curves upward and meets the lower margins of the upper surface in a rounded angle.

Although the structure is similar to that of *C. americana*, it is coarser. The distance between the successive basal platforms at their periphery is about 0.2 mm. on the average, while the distance in *C. americana* is about 0.125 mm., a little more than half as much. The number of short lamellae that project inward between the peripheral platforms is about seven for each interspace, with a maximum length of about 0.15 mm., about the same as in *C. americana*. Although these processes are crowded, there is little or no anastomosis and the spaces between them are open. The absence of secondary compacting material constitutes a difference from typical *Cushmania;* but as has been remarked, there appears to be

intergradation between the two conditions. There is no second or inner wall, such as occurs in "*Chapmania*" (Silvestri, **12**, pl. 1, figs. 1–5).

Geologic horizon and locality.—Eocene, J. 22 M., Fontabella, at River Rise, Trelawny. *Cushmania fontabellensis* occurs in the same material with the specimens above referred to *C. americana*.

Genus LITUONELLA Schlumberger

LITUONELLA, sp.

Plate 43, fig. 7

There are at several localities small conical arenaceous Foraminifera with an excentric coil at the apex similar to Schlumberger's figure of *Lituonella roberti* (Schlumberger and H. Douvillé, **11**, figs. 1–3). The specimens are of two shapes, one with an obtuse, the other with an acute apex; but those of each shape have similar initial coils. The smaller of the more obtuse specimens have a basal diameter of 1 mm. and are 1 mm. tall; larger specimens may have a basal diameter of 3 mm. and a height of 2.25 mm. The more acute specimens may be 2 mm. in diameter at the base and 2.25 mm. tall. It is possible that the more acute specimens are *Coskinolina*. Attempts to make sections of individual specimens of the limited quantity of available material were not entirely satisfactory. The more obtuse specimens appear to belong to *Lituonella* and to be represented in section by plate 43, figure 7. The difference between the structure of the specimens represented by these figures from those of *Dictyoconus* and *Cushmania* is too obvious to require special comment.

Geologic horizon and localities.—Middle Eocene "Yellow limestone," from localities J. 504 M., Mount Prospect bridle road from Spice Grove, boundary of parishes of St. Elizabeth and Manchester, and J. 605 M., Davyton Road at $4\frac{7}{8}$ mile post, Peace River district, parish of Clarendon.

Family ORBITOIDIDAE

Genus MIOGYPSINA Sacco

MIOGYPSINA BRACUENSIS Vaughan, n. sp.

Plate 45, figs. 1–3

Test compressed, ovate in plan, slightly asymmetric with reference to the equatorial plane. Macrospheric form: length, 2 mm.; width, 1.5 mm.; thickness, about 0.70 mm. Surface minutely papillate, papillae between 0.037 mm. and 0.05 mm. thick and slightly farther apart than their thickness.

Two equal or subequal embryonic chambers, apically situated but slightly interior, 0.025–0.05 mm. from the actual periphery. Distance across the two chambers 0.25–0.30 mm.; greater diameter of a single chamber as much as 0.2 mm.; walls thick, about 0.025 mm. The initial chambers are succeeded by five or six smaller chambers which are intermediate in character between the initial chambers and the usual equatorial chambers and are cyclically arranged around the inner of the two initial chambers.

The equatorial chambers are small, irregularly polygonal in plan, tetragonal, pentagonal, or hexagonal, the greater diagonal ranging from about 0.12 to 0.15 mm. The thickness of the equatorial layer is rather uniformly 0.16 mm.; and the length of the chambers is, as given above, about 0.125 mm. Very fine cribriform perforations, similar to those figures for *M. cushmani*, are present (Vaughan, **14,** pl. 36, fig. 6).

The lateral chambers are not in definite layers but are imbricately laid down one over another. The number of chambers along a vertical line ranges from three to five, length less than that of the equatorial chambers. Minute cribriform perforations present.

Geologic horizon and locality.—Montpelier white limestone, J. 26 M., chalk pit on Lancaster and Maria Buena Pen, near Braco, Trelawny. Associated with *Lepidocyclina canellei* Lemoine and R. Douvillé.

Including my paper (Vaughan, **14**) three species of *Miogypsina* had been described from the American Tertiary formations up to 1924. They were *M. panamensis* (Cushman), *M. antillea* (Cushman), and *M. cushmani* Vaughan. Subsequently three other species have been described. They are *M. staufferi* Koch (**10,** 1926) and *M. hawkinsi* and *M. venezuelana* Hodson (**9,** 1926). Of the six species mentioned, without going into detail all can be eliminated from the present discussion except *M. hawkinsi* Hodson from the Oligocene-Miocene of the district of Buchivacoa, state of Falcón, Venezuela. The species here described differs from *M. hawkinsi* by its more ovate outline in plan; by having a much more finely papillate surface; and because of the fact that, according to Mrs. Hodson's figure of the embryonic and equatorial chambers of *M. hawkinsi* (**9,** pl. 8, fig. 1, 1926), the embryonic apparatus and the succeeding accessory chambers are different in the two forms. In *M. bracuensis* the five or six accessory chambers which lead from the outer of the two embryonic chambers and around the margin of the inner embryonic chamber appear characteristic. As the sections are cut, either the outer or inner of the two embryonic chambers may be slightly larger than the other.

Genus DISCOCYCLINA Gümbel

Specimens of *Discocyclina* are usually present in the limestones and marls of Eocene age in Jamaica, as is the case elsewhere in the Eocene deposits of the West Indies and of the continental areas of the Caribbean region; but, as the actual identification of species is usually uncertain in thin sections, only a few forms have been specifically determined.

DISCOCYCLINA CRASSA (Cushman) Vaughan

Orthophragmina crassa, Cushman (**3,** p. 53, pl. 9, figs. 4, 5; pl. 10, figs. 2, 4).
Discocyclina crassa, Vaughan (**14,** p. 792).

Specimens identified as belonging to this species were obtained from locality J. 58 M., west of Borehole, Hyde, Trelawny, in association with *Lepidocyclina macdonaldi* Cushman and *Asterocyclina*. The horizon is, therefore, upper Eocene.

DISCOCYCLINA, sp., aff. D. PUSTULATA (Cushman) Vaughan

Orthophragmina pustulata, Cushman (**3**, p. 55, pl. 9, fig. 7; pl. 10, fig. 1).
Discocyclina pustulata, Vaughan (**14**, p. 792).

Specimens that resemble *D. pustulata* were found in the same sample of rock as *D. crassa* at J. 58 M.; see above.

DISCOCYCLINA PERKINSI Vaughan, n. sp.

Plate 46, figs. 4, 5

Test flat-lenticular, 6.5–7.0 mm. in diameter and 0.7 mm. thick, the diameter about 10 times the thickness; there is gradual thinning near the edges, but throughout most of their extent the two faces are nearly parallel to each other. There is no central boss. The outer surface is nearly smooth, as the papillae are very small.

There are two embryonic chambers exposed in a vertical section, one somewhat larger than the other. The smaller is 0.15 mm. long by 0.10 mm. high; the larger, 0.20 mm. long by 0.125 mm. tall. Their longer axis is slightly inclined to the equatorial plane. There is a constriction where the two chambers join, suggesting two ovoids or ellipsoids joined by contiguous ends with but little flattening at the junction. A horizontal section shows a smaller chamber partially embraced by a larger.

The equatorial chambers are very small, about 0.01 mm. tall; and there are about two annuli to 0.05 mm., or an annulus is about 0.025 mm. across. The equatorial layer is of virtually the same thickness from the embryonic chambers to the periphery. In plan the chambers are minute, neat rectangles.

The lateral chambers are very low and crowded; about thirty were counted in a tier 0.37 mm. tall, or there is about one chamber to 0.012 mm. There are very minute pillars, which are about 0.025 mm. thick near their outer ends.

Geologic horizon and locality.—Upper Eocene calcareous marl, J. 59 M., Kinloss, near Duan Vale, Trelawny. Collected by R. F. Perkins, for whom the species is named.

Previously five flat or nearly flat species of *Discocyclina* have been described from America, viz., *D. clarki*, *D. flintensis*, *D. floridana*, and *D. advena* of Cushman, and *D. miranda* Hodson. *D. clarki* and *D. flintensis* both have a central boss: *D. floridana* has no central boss, but it has a rather coarsely papillate surface; *D. advena* has a thinner central part with a thicker surrounding part which thins peripherally; *D. miranda* is a very much smaller form. *D. perkinsi* is decidedly different from any other American species.

Genus ASTEROCYCLINA Gümbel

Asteriacites, Vaughan (**14**, 798). *Cisseis*, Hodson (**8**, 1926).

In my paper referred to above it was shown that *Asteriacites* Schlotheim, 1822, antedated *Asterodiscus* Schafhäutl, 1863, and that Ehrenberg, 1838, had already used *Asterodiscus* and that that name was preoccupied. I, therefore, used *Asteriacites* for the stellate "Orthophragmina." Mrs. Hodson, in her paper cited above, states that Schlotheim in 1820 used the name *Asteriacites* for three species, none of

which belongs to the Foraminifera; and she, therefore, rejects the name for that group of organisms. She proposes to use the name *Cisseis* of R. J. L. Guppy, 1866. Reference to Scudder's *Nomenclator Zoölogicus* shows that *Cisseis* had been applied to a genus of *Coleoptera* in 1839. Dr. C. W. Stiles has kindly sent me the following reference: "*Cisseis* La Porte and Gory, 1839, fide (each genus paged separately). Hist. nat. et écon. Ins. coléoptères, Paris, pp. 1–5," *Cisseis* is, therefore, not available; and I am consequently using the name *Asterocyclina* proposed by Gümbel, 1868. I will remark in passing that I believe that the forms here designated *Asterocyclina* differ only subgenerically from typical *Discocyclina*.

Specimens of *Asterocyclina* are very abundant in the Eocene, apparently upper Eocene, rocks of Jamaica. I have listed the genus from at least seven of Dr. Matley's localities; but since most of the specimens are embedded in rock the identification of species is impracticable, if not even impossible, with few exceptions. In fact, it was not always possible to be sure whether a specimen was *Asterocyclina* or *Discocyclina*.

ASTEROCYCLINA GEORGIANA (Cushman) Vaughan

Orthophragmina georgiana, Cushman (**1**, p. 117, pl. 41, figs. 2, 3; pl. 42, fig. 3; pl. 43, figs. 2, 3).

Asteriacites georgiana, Vaughan (**14**, p. 793).

In the collection from J. 6 M., Kinloss road at 29.25-mile post, Trelawny, there are several specimens of a four-rayed species that can be confidently identified as *A. georgiana*. The specimens are delicate and closely resemble those found in the Ocala limestone on Chipola River at Marianna, Florida. In the pieces of rock from J. 6 M. there is a natural section of a species of *Discocyclina*, in which the nephrolepidine embryonic chambers are shown. This species is suggestively like *D. flintensis* (Cushman). It is clear that the horizon of this exposure is upper Eocene and that it represents a part, probably the upper part, of the Ocala limestone of Florida and Georgia.

ASTEROCYCLINA, sp. indet.

Plate 44, fig. 4; plate 50, fig. 2

Two specimens of *Asterocyclina* are figured, as is indicated above. Both are in the same piece of rock as the cotypes of *Lepidocyclina haddingtonensis*, n. sp., from J. 67 M., "Deep Gully" of Rio Bueno, above second gully, Trelawny. Some of these specimens may be *A. antillea* (Cushman); smaller specimens, not figured, may belong to *A. subtaramellei* (Cushman) and *A. asteriscus* (Guppy), but there is no profit to be gained by trying to guess the species.

Genus LEPIDOCYCLINA Gümbel

Subgenus PLIOLEPIDINA H. Douvillé

LEPIDOCYCLINA (PLIOLEPIDINA) KINLOSSENSIS Vaughan, n. sp.

Plate 47, figs. 1–6

Test rather small, compressed lenticular; diameter, 5–5.2 mm.; thickness, 0.75–1.25 mm.; on the surface of the central part there are strong papillae, which

are as much as 0.15 mm. thick. The edges are thin; for a distance of about 0.5 mm. the peripheral part of the test has no lateral over the equatorial chambers.

The embryonic chambers appear to be of the *Pliolepidina* type, one larger and several smaller chambers, more or less spirally arranged around the larger; but one specimen has two nearly equal larger chambers and smaller accessory chambers. The total width of the embryonic apparatus is as much as 0.50 mm.; height, 0.25 mm.

The equatorial chambers at the margin of the embryonic chambers are 0.10 mm. tall and 0.075 mm. wide; at the periphery of the text, the height is 0.20 mm.; width, 0.10; or the height is twice the width. In plan, the form is either with outer convex wall or the shape is rhomboid. The perforations in the chamber walls are very minute and numerous, ten or a little more in about 0.20 mm., or about one to 0.02 mm.

The lateral chambers form relatively few layers, there being only five or six over the center of the test. The walls between the successive chambers in a tier are so excessively thick as to obliterate, or almost to obliterate, the chamber cavities. The height of the cavities, where they are not obliterated, is usually 0.02 mm. or less; 0.01 mm. is a rather common height. The walls between successive cavities, where they can be distinguished in a tier, are as much as 0.04 mm. thick. The length of the chamber cavities is as much as 0.10 mm., or the length is 10 times the height. There are stout pillars which thicken from their inner ends outward, the outer measuring as much as 0.15 mm. in diameter.

Geologic horizon and locality.—Eocene, associated with *Discocyclina*, sp., probably *D. perkinsi* Vaughan. J. 14 M., Kinloss North road, near Duan Vale road, Trelawny Parish, Jamaica; collected by C. A. Matley.

Lepidocyclina kinlossensis in vertical sections resembles *"Lepidocyclina" antillea* Cushman. The equatorial chambers of the two, however, are strikingly different. Those of *L. kinlossensis* are distinctly lepidocycline, as has been indicated; whereas those of *"L." antillea* are not lepidocycline but resemble the equatorial chambers of *Omphalocyclus*. The characteristics of the embryonic chambers of *"L." antillea* are unknown.

Subgenus LEPIDOCYCLINA Gümbel

LEPIDOCYCLINA (LEPIDOCYCLINA) SHERWOODENSIS Vaughan, n. sp.

Plate 48, figs. 4–8

Test small to rather small in size, lenticular with a thin projecting edge. Both microspheric and macrospheric specimens are abundant. The margin of the largest microspheric specimen is broken; the diameter of this specimen is about 3.8 mm.; thin edge on each side projects about 0.50 mm.; thickness, 1.3 mm. A smaller, perfect specimen is 3.15 mm. in diameter, 0.75 mm. thick; free edge projects 0.75 mm. There are small papillae on the surface. The macrospheric form ranges from 1.5 to about 2 mm. in diameter and is about 0.5 mm. thick; the thin edge, about 0.4 mm. wide. The diameter ranges between 3 and 4 times the thickness.

The embryonic chambers are two in number and are equal or subequal. The length of the two chambers in the equatorial plane is about 0.40 mm.; height, 0.20–0.25 mm. Some specimens have smaller chambers, but in these the sections may have been to one side of the longer axis. In one such specimen, length 0.30, height 0.20 mm.; in another, length 0.25, height 0.15 mm.

The equatorial chambers in the microspheric form are about 0.025 mm. high and about as wide; at the periphery, 1.75 mm. from the center, the height is about 0.125 and the width about 0.075 mm. In the macrospheric form the chambers next the embryonic chambers are slightly larger than the central chambers of the microspheric form. In plan the equatorial chambers are rhomboid. Because the substance of the test has undergone recrystallization, the perforations in the walls of the equatorial chambers are indistinct; but they appear to be less numerous than is usual in *Lepidocyclina*.

The height of the lateral chambers is moderately regular and uniform, but the width is decidedly irregular. The number of chambers in a tier about 0.6 mm. tall over the center in the largest microspheric specimen is between eleven and thirteen, or there is about one chamber to 0.05 mm. in height; in a small macrospheric specimen there are four chambers in 0.20 mm., or one chamber in 0.05 mm. The walls between the successive chambers in a tier are thin, and the chamber spaces are open. There is no noticeable thickening of the walls at their ends. The vertical walls between the chambers vary greatly in thickness; and this with an irregular development of pillars affects the width of the lateral chambers, which ranges from 0.05 to 0.30 mm., being greatest near the periphery. The columns in the large microspheric specimen attain a maximum thickness at their outer ends of 0.10–0.15 mm., about 0.07 mm. more common. Not all the columns extend to the surface of the test. Between the peripheral ends of many successive chamber walls there are small wedge-like projections into the chamber cavities from the pillars or vertical walls between adjacent chambers. The two last-mentioned features give to the vertical sections of the test a distinctly ragged appearance.

Geologic horizon and locality.—Eocene, J. 57 M., Sherwood, Trelawny, Jamaica; collected by Dr. C. A. Matley. Associated with *Discocyclina* or *Asterocyclina*.

Lepidocyclina sherwoodensis is one of the small, lenticular species with two equal or subequal embryonic chambers and rhomboid equatorial chambers. The related species are *Lepidocyclina pustulosa* H. Douvillé (form A) and *L. trinitatis* H. Douvillé (form A), from both of which it differs by the raggedness of its features as exhibited in vertical sections.

LEPIDOCYCLINA (LEPIDOCYCLINA) MACDONALDI Cushman

Cushman (**4**, p. 77, pl. 34, figs. 1–3). Vaughan (**14**, p. 797).

Dr. Matley collected specimens of this species at three different localities in the Eocene of the parish of Trelawny, viz., J. 5 M., Hyde, north of Haddington; J. 11 M., Swanswick Great House slopes, and J. 58 M., west of Borehole, Hyde.

It is associated with *Discocyclina*, *Asterocyclina*, *Lepidocyclina trinitatis* and *L. haddingtonensis*, n. sp. The indicated horizon is upper Eocene.

LEPIDOCYCLINA (LEPIDOCYCLINA) TRINITATIS H. Douvillé

Plate 49, figs. 11–13

Isolepidina trinitatis, H. Douvillé (**6**, p. 34, pl. 1, fig. 1, text figs. 7–12).
Lepidocyclina (*Lepidocyclina*) *trinitatis*, Hodson (**9**, p. 19, pl. 4, fig. 10).

The following is a rather full description of specimens abundant at some localities in the Eocene of Jamaica:

Test small, robustly lenticular, without marginal thin edge. The macrospheric form has a diameter 2.25–3 mm.; thickness, about one-half the diameter, from 1 to 1.5 mm. Surface with a few strong bosses produced by the emergent distal ends of pillars.

Embryonic chambers of the isolepidine type. There are two equal or subequal larger chambers, partly surrounded by several smaller chambers which are larger than the adjacent equatorial chambers. The length of the embryonic chambers is as much as 0.5 mm.; height, 0.25 mm.

The equatorial chambers in vertical section are nearly square at the center, about 0.05 mm. wide and high; at the periphery, they are about 0.06 mm. wide and 0.10 mm. high.

Lateral chambers numerous, rather uniform in height and rather equally spaced in the vertical tiers, but not uniform in length because of the strongly developed pillars. In a vertical tier 0.75 mm. tall there are ten chambers, or one chamber to 0.075 mm. The length of the chambers ranges from 0.05 mm. near the center to as much as 0.2 mm. at the periphery. The walls between the chambers in the vertical tiers are uniformly rather thick, about 0.025 mm. Especially over the center there are stout pillars, which become thicker distally. The maximum thickness at the outer ends ranges between 0.15 and 0.25 mm. These pillars interrupt the horizontal development of the lateral chambers and introduce irregularity in their width.

Geologic horizon and locality.—Eocene, J. 11 M., Swanswick Great House slopes, Trelawny. Associated with *Lepidocyclina macdonaldi*.

The specimens above described are macrospheric, from locality J. 11 M., as given above. The species also occurs at locality J. 65 M., Jock's Lodge, Duan Vale, Trelawny, from which two specimens are figured (plate 49, figs. 12, 13). One of these (plate 49, fig. 13) is obviously microspheric; it is about 5 mm. in diameter and 3 mm. thick. A specimen, not figured, has two equal embryonic chambers.

The specimens so far considered have strongly developed pillars and relatively large papillae on the surface. The same variety is abundant in the upper Eocene of Chiapas, Mexico, Salto de Agua-Paso Limar road, department of Palenque, and near that locality at a place 4.5 km. north and 5.5 km. west of Trinidad. A variety without so strongly developed pillars is found on Rio Vinazco, canton of Chicontepec, state of Vera Cruz, and in Panama near David. The species is widely distributed in the upper Eocene of the Caribbean region and in tropical Mexico.

It is probable that the *L. trinitatis* occurs at other localities in Jamaica than those above listed. J. 58 M., west of Borehole, Hyde, Trelawny, will be mentioned. There are at this locality specimens not so robust as those from J. 11 M. and J. 65 M. and pillars are not so well developed, but they are probably referable to the same species. They are associated with *Discocyclina*, *Asterocyclina*, and *Lepidocyclina macdonaldi*.

LEPIDOCYCLINA (LEPIDOCYCLINA) CANELLEI Lemoine and R. Douvillé

Plate 49, figs. 1–5, 7–9

Cushman (**4**, p. 75, pl. 32, figs. 1–5). Vaughan (**14**, p. 797, pl. 33, fig. 4).

Dr. Matley obtained a number of specimens that resemble *L. canellei* too closely for reference to another species. These specimens will be discussed in detail.

Plate 49, figure 8, illustrates a specimen from locality J. 29 M., Montpelier white limestone, at Friendship, Trelawny. This figure should be compared with Cushman's figure 3 cited above.

The same species is also found at locality J. 43 M., Brampton Bryan, west of Quaco Gully, Trelawny.

A group of specimens which differ somewhat from typical *L. canellei* will be described in detail. They are from J. 56 M., First Hill, Jackson Town, Trelawny, and are illustrated by plate 49, figures 1–5. The description is as follows:

Test small, discoid, somewhat asymmetrical with reference to the equatorial plane. Macrospheric form: diameter, 2.5 mm.; thickness, about 1 mm.; surface apparently without papillae. Microspheric form: diameter, 3 mm.; thickness, 1.25 mm.

Embryonic chambers, two, equal, small, divided by a straight wall. Diameter of single chamber in vertical plane, 0.1 mm.; length of the two chambers, 0.15 mm.; peripheral wall relatively thick for the small size of the chambers, about 0.012 mm.

Equatorial chambers distinctly and neatly hexagonal; slightly increasing in size from the center toward the periphery; near the center, height 0.05 mm., radial diameter about 0.035 mm.; at the periphery, height about 0.10 mm., radial diameter 0.05–0.075 mm. Perforations in the walls of the equatorial chambers obscured by recrystallization, apparently minute and crowded.

Lateral chambers regular in size and distribution, nine in a tier in the central area of the test, length of tier 0.35 mm., therefore about one chamber to 0.04 mm.; radial length of the chambers, 0.05–0.075 mm. The chambers are slightly, but not greatly, longer than high. They are developed to the periphery of the test, but at the periphery they are only one layer thick. The walls between the chambers are thin, and there are no indications of pillars.

A specimen which shows coarse papillae is illustrated by figure 6 of plate 49. It may be a variant of, or different from, *L. canellei*.

Plate 49, figures 7 and 9, illustrates two specimens from the Montpelier white limestone, at J. 26 M., Montpelier white limestone, chalk pit, on Lancaster and Maria Buena Pen, near Braco, Trelawny. The specimens are silicified, and the one represented by figure 7 has undergone considerable change. The specimen illus-

trated by figure 9 resembles very closely those from J. 56 M. *Miogypsina bracuensis* is found in the same rock specimens with *L. canellei* at J. 26 M.

The determination of the geologic age of the Montpelier white limestone at the three localities, J. 26, 29, and 43 M., depends on the identification of the species of the *Lepidocyclina* here discussed and on the presence of the species of *Miogypsina*. The horizon appears to me to be very high Oligocene or even lower Miocene; and it seems to me to be the same as that of J. 56 M., which Dr. Matley refers to the Moneague. From these statements it appears that at least a part of the Montpelier is stratigraphically equivalent to a part of the Moneague, the difference consisting chiefly in difference in lithologic facies.

LEPIDOCYCLINA (LEPIDOCYCLINA) YURNAGUNENSIS Cushman

Cushman (**4**, p. 76, pl. 32, figs. 6, 7). Vaughan (**14**, p. 798, pl. 33, fig. 8; **16**, p. 391, pl. 25, figs. 2–6.)

Specimens referable to this species were obtained by Dr. Matley in the Moneague formation at J. 4 and 84 M., Roadside Quarry, near 30-mile post, Ocho Rios road, north of Moneague, parish of St. Ann. The specimens are entirely typical (Vaughan, **14**, pl. 33, fig. 8; **16**, pl. 25, figs. 2, 3). In the pieces of rock are abundant specimens of *Lepidocyclina* (*Nephrolepidina*) *undosa* Cushman and specimens of *Lepidocyclina* referred to as *L. gigas* variety on a subsequent page of this paper. The association of *L. undosa* and *L. yurnagunensis* is identical with the association in Cayman Brac. The horizon is Antiguan Oligocene.

In the same thin section with *L. yurnagunensis* is one excellent section of a specimen of the kind referred by Cushman to *L. morgani* (Cushman, **4**, p. 74, pl. 33, figs. 12–14; cf. especially fig. 12). Specimens having the gross external features of *L. morgani* are common in the Oligocene of Cuba, the Meson formation of Mexico, and the Antigua formation of Antigua. Some of the specimens are variants of *L. parvula* Cushman; and I think others may be variants of *L. yurnagunensis*. Some specimens of *L. parvula* approach *L. giraudi* very closely. The relations of the *L. morgani*-like forms have not yet been sufficiently studied. However, the presence of such a form in Jamaica at the locality above noted is additional evidence of the deposits at that locality being the correlative of Oligocene deposits in Antigua, Cuba, and Mexico.

LEPIDOCYCLINA (LEPIDOCYCLINA) MIRAFLORENSIS Vaughan

Vaughan (**13**, p. 257; **17**, p. 4, pl. 4, figs. 3–5).

Specimens of this species are present in material collected in the Moneague formation at J. 75 M., Ulster Spring road, 1.5 miles above Jackson Town, Trelawny, where it is associated with *L. gigas*, *L. forresti*, and an Antiguan Oligocene species of *Operculinella*. The horizon is Antiguan Oligocene.

LEPIDOCYCLINA (LEPIDOCYCLINA) FORRESTI Vaughan

Vaughan (**17**, p. 1, pl. 1, figs. 1–4; pl. 2, figs. 1–6).

Specimens of *L. forresti* occur at J. 75 M. in association with *L. miraflorensis* as given above.

LEPIDOCYCLINA (LEPIDOCYCLINA) PARVULA Cushman

Cushman (**3**, p. 58, pl. 3, figs. 4-7). Vaughan (**14**, p. 797).

A specimen, very nearly a duplicate of Cushman's plate 3, figure 5, cited above, was obtained in the Moneague formation at locality J. 68 M., where it is associated with *L. undosa* as in Antigua and in the Meson formation of the state of Vera Cruz, Mexico. *L. parvula* is an abundant and widely distributed species at this horizon.

LEPIDOCYCLINA (LEPIDOCYCLINA) MATLEYI Vaughan, n. sp.

Plate 46, figs. 1–3

Test rather small, 4–5 mm. in diameter, 0.9–1 mm. thick in the center, selliform; surface with some small papillae.

Embryonic chambers, two, subequal or one larger than the other, separated by a straight partition. Maximum diameter of the larger chamber, 0.3 mm.; length of the two chambers, 0.4 mm.; chamber wall thick, about 0.05 mm.

Equatorial chambers, distinctly and neatly hexagonal, increasing in height and radial diameter from the center toward the periphery. At margin of the embryonic chambers, radial diameter about 0.025 mm., height about 0.05 mm. Two millimeters from the embryonic chambers, radial diameter 0.10 mm., height 0.15. Walls between the equatorial chambers minutely cribriform, ten or more perforations in 0.05 mm.

Lateral chambers, about seven in a tier near the center, length ranges from somewhat greater than the height to twice the height; the number in a tier decreases toward the periphery and near the periphery the equatorial are not covered by lateral chambers, the uncovered equatorial chambers may project as much as 0.5 mm. beyond the lateral chambers.

Columns may or may not be present between the lateral chambers; occasionally they may be as thick as 0.1 mm. at the distal end, but this is exceptional; 0.025 mm. or even less is usual.

Geologic horizon and locality.—Oligocene, Moneague formation, J. 20 M., above Martha Brae River, probably from Retreat, Trelawny Parish.

This species seems entirely peculiar. Its nearest relative is the Eocene *L. floridana* from the Ocala limestone of Florida.

Subgenus NEPHROLEPIDINA H. Douvillé

LEPIDOCYCLINA (NEPHROLEPIDINA) HADDINGTONENSIS Vaughan, n. sp.

Plate 50, figs. 1–2

This species is represented by both microspheric and macrospheric specimens. The test is rather large and relatively flat. The semidiameter of the microspheric form somewhat exceeds 8 mm.; the entire diameter, therefore, is approximately 16 mm.; the thickness is about 2.70 mm. The surface is coarsely and roughly papillate, the papillae being as much as 0.25 mm. in diameter and about the same distance apart. The semidiameter of the macrospheric form is 5 mm., the full diameter, therefore, being about 10 mm.; thickness through the center, 1.5 mm.

Outside the central thickening the test thins to a thickness of 0.5 mm., and there is a thinner edge, 1.75 mm. wide, composed of equatorial chambers without any covering of lateral chambers. There are strong papillae on the macrospheric form, but they are more distant than on the microspheric form, about 0.5 mm. apart, and not quite so thick.

The embryonic chambers are of nephrolepidine type, one larger chamber partly embracing a somewhat smaller one; they are decidedly large and the outer wall is strikingly thick. The height of the larger chamber in a vertical section is about 1 mm.; width of the two chambers in the equatorial plane, about 0.9 mm. In another specimen the larger chamber is about 1 mm. long in the equatorial plane and about 0.62 mm. high. The orientation of the axes of the chambers is not uniform.

Near the center, the equatorial chambers are about 0.075 mm. tall and about as wide as high or a little wider than high. At the periphery of the macrospheric form, the height is about 0.125 mm.; width, about 0.010 mm. In the microspheric form, the height at the periphery is 0.25 mm.; width, about 0.15 mm. In plan the chambers are either hexagonal or there is a curved outer wall and converging inner walls. Walls of the chambers are minutely cribriform.

There are only four or five layers of lateral chambers over the centers in the macrospheric forms, but in the microspheric forms there are about fifteen layers. The lateral chambers are not uniformly disposed in regular tiers; some tiers extend regularly from the equatorial plane to the periphery; but many, or most, are interrupted and the walls between the successive chambers are not uniform in thickness and are somewhat undulate. Near the equatorial plane the chamber cavities are much constricted by secondary thickening of the lower and upper walls, which are thinner toward the outer surface. The chambers vary greatly in length, from 0.10 to 0.70 mm. The vertical walls between the chambers are also irregular, as would be inferred from the great variation in the length of the chambers.

Strong pillars are present, they are of about the same thickness throughout their length and are composed of course, upwardly diverging fibers. The thickness ranges from 0.15 to 0.25 mm. Distance apart not uniform, ranges from about 0.25 to 0.75 mm.

Geologic horizon and locality.—Upper Eocene, J. 67 M., Deep Gully of Rio Bueno, above second gully (cotypes). Also at J. 5 M., Hyde, north of Haddington; J. 11 M., Swanswick Great House slopes; J. 14 M., Kinloss North road, near Duan Vale road; J. 58 M., west of Borehole, Hyde—all localities in Trelawny Parish. Species associated with *L. haddingtonensis* include *Dictyoconus puilboreauensis*, *Discocyclina*, *Asterocyclina*, *Lepidocyclina macdonaldi*, *L. trinitatis*, *L. kinlossensis*, and L. sp., cf. *L. perundosa*. The horizon is obviously upper Eocene.

There are two American Eocene species of *Lepidocyclina* that are definitely known to have nephrolepidine embryonic chambers. They are *L. chaperi* Lem. and R. Douvillé and *L. fragilis* Cushman, and it appears that *L. perundosa* Cush-

man is also a species of *Nephrolepidina*. The outer embryonic chamber in *L. chaperi* only slightly embraces the inner chamber; but in both *L. fragilis* and *L. haddingtonensis* the outer chamber passes around a considerable part of the periphery of the inner. Illustrations of vertical sections of *L. fragilis* have not yet been published, but I have had sections cut and photographed. The texture of *L. fragilis* is much more uniform than that of *L. haddingtonensis*, and the pillars are not so prominently developed. The sections are strikingly different.

In passing, it will be noted that the horizon of *L. fragilis* is the very top of the Ocala limestone on Chipola River at Marianna, Florida. *L. fragilis* is also abundant in the Tantoyuca formation of the state of Vera Cruz, Mexico, where both macrospheric specimens, with nephrolepidine embryonic chambers, and microspheric specimens were collected by me.

LEPIDOCYCLINA, sp., cf. L. (NEPHROLEPIDINA) PERUNDOSA Cushman

Plate 48, figs. 1, 2

Cushman (**2**, p. 63, pl. 11, fig. 8). Vaughan (**14**, p. 797).

Two specimens from the upper Eocene at locality J. 58 M. west of Borehole, Hyde, Trelawny, are compared with *L. perundosa* from the Eocene of Nuevitas, Cuba. It should be pointed out, however, that the lateral chambers are relatively more open than those in the specimen from Cuba and that the floors and roofs of the chambers in the type-specimen of the species are more wavy. Although of similar form and size to *L. perundosa* the Jamaican specimens may represent a different species.

LEPIDOCYCLINA (NEPHROLEPIDINA) UNDOSA Cushman

Plate 48, fig. 3

Cushman (**4**, p. 68, pl. 26, fig. 2). Vaughan (**14**, p. 798, pl. 34, figs. 5–7; **16**, p. 393, pl. 24, figs. 1, 2; *idem*, var. *tumida*, p. 393, figs. 3–5).

This is one of the two commonest forms of *Lepidocyclina* in the Moneague formation in Jamaica. Dr. Matley collected it from at least twelve different localities, as follows:

J. 1 M. Dry River Sink, south of Sawyers, Trelawny
J. 3 M. Near Westwood School gate, Trelawny
J. 4 M. and J. 84 M. Roadside Quarry, near 30-mile post, Ocho Rios road, north of Moneague, St. Ann
J. 25 M. Deep Gully road, Brampton Bryan, Trelawny
J. 43 M. Brampton Bryan, west of Quaco Gully, Trelawny
J. 46 M. Stewart Town, Trelawny
J. 55 M. Westwood Hill, at mile 62, Trelawny
J. 58 M. Rio Bueno road, 0.75 miles north of Jackson Town, Trelawny
J. 72 M. Main road, north of Ulster Spring, below 17-mile post, Trelawny
J. 74 M. Jackson Town-Ulster Spring road, near 10-mile post, Trelawny
J. 80 M. Two miles west of Brownstown, Stewart Town road, St. Ann
J. 88 M. Pleasant Valley, south end of village, Clarendon

Most of the specimens are entirely typical, but some belong to the varietal form which I designated variety *tumida*, for instance at J. 1 and 4 M.; but the

intergradation between the forms is so complete that it does not seem worth while to separate them, although that procedure appeared desirable in describing the material from Cayman Brac.

LEPIDOCYCLINA GIGAS Cushman

Cushman (**4**, p. 63, pl. 19, figs. 1, 2, 3 [not fig. 4]). Vaughan (**14**, p. 799; **16**, p. 396, figs. 1 *a*, 1 *b*).

This form occurs at the following localities at which *L. undosa* was collected: J. 1, 3, 4, 46, 68, and 75 M., that is at six of the twelve localities at which *L undosa* was found. I have twice expressed the opinion that *L. undosa* is the macrospheric and *L. gigas* the microspheric form of the same species, but that opinion cannot be regarded as absolutely proved. Therefore, I continue to treat the two forms as if they were valid species. As a part of additional studies in progress of collections from Antigua and Mexico, satisfactory criteria for a definite decision may be ascertained. In a paper recently published by H. Douvillé (**7**, p. 35), he refers *L. undosa* from the Meson of Mexico to *L. dilatata* and *L. gigas* var. *mexicana* to *L. raulini*. Professor Douvillé's (**7**, fig. 3) figure of the embryonic chambers of *L. undosa* is virtually identical with the figure I published (**16**, pl. 34, fig. 7). I pointed out that embryonic chambers of the Mexican specimens are more truly eulepidine than those of the Antiguan specimens, but there appears to be variation in the degree of the extension of the outer around the inner chamber.

LEPIDOCYCLINA GIGAS Cushman, var.

At localities J. 1, 4, 75, and 79 M., there are specimens of *Lepidocyclina gigas*-facies, which differ from typical *L. gigas* by being relatively thinner and by having rather longer lateral chambers and weaker pillars. A specimen from J. 75 M. is about 18 mm. long, 2.2 mm. thick at the inner edge, and about 0.5 mm. thick at the margin. The inner end does not reach the center. The diameter, therefore, exceeds 36 mm. The lateral chambers are irregular in length, but the maximum is about 0.4 mm. Pillars are very weakly developed. The equatorial chambers do not show notable differences from typical *L. gigas*. These specimens require further study. They may be only a very much flattened variety of *L. gigas*, but it is possible that they should be referred to a different species.

The numbers of all the localities represented except J. 79 M. are explained under *L. undosa*. J. 79 M. is 0.25 miles north of Brownstown, St. Ann, Moneague formation.

LEPIDOCYCLINA (NEPHROLEPIDINA) CRASSATA Cushman

Plate 45, figs. 4, 5

Cushman (**3**, p. 61, pl. 11, figs. 4, 5, text-fig. 8; **4**, p. 74, pl. 31, figs. 3–6). Vaughan (**14**, p. 798, pl. 34, figs. 3, 4).

The relations of three reputed species of *Lepidocyclina*, now designated *L. crassata* Cushman, *L. chattahoocheensis* Cushman, and *L. marginata* (Micht) *teste* Cushman, need critical restudy. All belong to the subgenus *Nephrolepidina*, and they are all closely related, if not identical. Dr. Matley collected specimens that

belong in this group at his locality J. 4 M., Ocho Rios road, near 30-mile post, north of Moneague; and at J. 23 M., Montpelier white limestone, Rio Bueno–Jackson Town road, at 5.25-mile post, Trelawny. Two specimens from the latter locality are illustrated on plate 45, figures 4 and 5. These specimens have embryonic chambers similar to those of *L. crassata*, but the pillars are not so thick as in the type specimen of *L. crassata*. There is, however, in the type material a specimen that has pillars similar to those of the Jamaican specimens; and another specimen (see my paper, pl. 34, fig. 3) also has similar pillars. The last mentioned specimen is the extreme right-hand one of the three illustrations published by Cushman in his text-figure 8 (**3**, p. 62, fig. 8). I am, therefore, applying without question the name *L. crassata* to the Jamaican specimens from the localities above mentioned.

The specimens figured are from silicified material of the Montpelier white limestone and furnish additional evidence of the Oligocene age of at least certain parts of that formation.

List of Literature Cited

1. Cushman, J. A., Orbitoid Foraminifera of the genus *Orthophragmina* from Georgia and Florida. U.S. Geol. Survey Prof. Paper 108, pp. 115–24, pls. 40–44. 1917.
2. ———, Lower Cretaceous age of the limestone underlying Florida. Wash. Acad. Sci. Jour., vol. 9, pp. 70–73. 1919.
3. ———, Fossil Foraminifera from the West Indies. Carnegie Inst. Wash. Publ. 291, pp. 21–71, 15 pls., 8 text-figs. 1919.
4. ———, American species of *Orthophragmina* and *Lepidocyclina*. U.S. Geol. Survey Prof. Paper 125, pp. 39–105, pls. 7–35, 1 text-fig. 1920.
5. ———, Occurrence of *Lituonella* and *Coskinolina* in America. Wash. Acad. Sci. Jour., vol. 17, pp. 198–99. 1927.
6. Douvillé, H., Revision des Lépidocyclines. France Soc. géol. Mém., n.s., vol. 1, mém. 1, pp. 1–49, 2 pls., text-figs. 1–48, 1924; pp. 51–123, 5 pls., text-figs. 49–83, 1925.
7. ———, Les Orbitoides de la région pétrolifère du Mexique. France Soc. géol. Compte rend. som., séance, 21 fevr., 1927, p. 34. 1927.
8. Hodson, Helen K., Names for the stellate "*Orthophragmina*." Amer. Jour. Sci., vol. 12, pp. 353–54. 1926.
9. ———, Foraminifera from Venezuela and Trinidad. Amer. Paleon. Bull., vol. 12, no. 47, pp. 46, 8 pls. 1926.
10. Koch, Richard, *Miogypsina staufferi*, nov. sp., from northwestern Venezuela. Eclog. Geol. Helvet., vol. 19, pp. 751–53, pl. 28. 1926.
11. Schlumberger, Ch., and Douvillé, H., Sur deux foraminifères éocènes: France Soc. géol. Bull., vol. 5, 4th ser., pp. 291–304, pl. 9, 7 text-figs. 1905.
12. Silvestri, A., Sulla diffusione stratigraphica del genera *Chapmania* Silv. e Prev. Acad. Lincei mem., 2d ser., vol. 8, pp. 31–60, pl. 1, 10 text-figs. 1925.
13. Vaughan, T. W., Studies of larger Tertiary Foraminifera from tropical and subtropical America. Nat. Acad. Sci. Proc., vol. 9, pp. 253–57. 1923.
14. ———, American and European Tertiary larger Foraminifera. Geol. Soc. Amer. Bull., vol. 35, pp. 785–822, pls. 30–36. 1924.
15. ———, The stratigraphic horizon of the beds containing *Lepidocyclina chaperi* on Haut Chagres, Panama. Nat. Acad. Sci. Proc., vol. 12, pp. 519–22. 1926.
16. ———, Species of *Lepidocyclina* and *Carpenteria* from the Cayman Islands. Geol. Soc. London Quar. Jour., vol. 82, pp. 388–400, pls. 24–26. 1926.

17. Vaughan, T. W., Larger Foraminifera of the genus *Lepidocyclina* related to *Lepidocyclina mantelli*. U.S. Nat. Mus. Proc., vol. 71, art. 8, pp. 1–5, pls. 1–4. 1927.

18. Woodring, W. P., Middle Eocene Foraminifera of the genus *Dictyoconus* from the Republic of Haiti. Wash. Acad. Sci. Jour., vol. 12, pp. 244–47. 1922.

19. ———, Some new Eocene Foraminifera of the genus *Dictyoconus*. Geol. Repub. of Haiti, pp. 608–10, pls. 9 and 13. 1924.

EXPLANATION OF PLATES 43–50

All figures, except plate 43, figures 1–5 *b* and figure 7, are enlarged 20 diameters. Magnification is given for only those figures that are not on that scale. The locality numbers are explained in the text under the descriptions of the species.

Plate 43

Figs. 1–5 *b*.—*Dictyoconus codon* Woodring. 1, 2, 3, vertical sections of three specimens, each ×10, to show variation, all in the same piece of rock from locality J. 504 M.; 4 *a*, 4 *b*, views of side and base, ×5, of a specimen with wider base, from locality J. 505 M.; 5 *a*, 5 *b*, views of side and base, ×5, of a more conical specimen, from locality J. 605 M.

6.—*Dictyoconus puilboreauensis* Woodring. Vertical section, ×20, specimen from locality J. 58 M.

7.—*Lituonella*, sp. Slightly oblique sections, ×10, of two specimens from locality J. 504 M.

Plate 44

Figs. 1, 2.—*Cushmania americana* (Cushman) Silvestri. 1, vertical section; 2, section of periphery near the apex of the specimen. Specimens from locality J. 22 M.

3.—*Cushmania fontabellensis* Vaughan. Vertical section of a specimen from J. 22 M.

4.—*Asterocyclina*, sp. Part of surface of a specimen from J. 67 M. See also pl. 50, fig. 2, from the same piece of rock. These specimens may belong to *A. antillea* (Cushman).

Plate 45

Figs. 1–3.—*Miogypsina bracuensis* Vaughan, n. sp. 1, vertical section; 2, two sections horizontal through the embryonic chambers show the five or six smaller chambers that extend from the outer embryonic chamber around the inner chamber; two oblique sections through specimens, one of which cuts the embryonic chambers; 3, slightly oblique section in a nearly horizontal plane. Specimens from locality J. 26 M.

4–5.—*Lepidocyclina* (*Nephrolepidina*) *crassata* Cushman. Two vertical sections, one through the embryonic chambers. Specimens from locality J. 23 M.

Plate 46

Figs. 1–3.—*Lepidocyclina* (*Lepidocyclina*) *matleyi* Vaughan, n. sp. 1, horizontal section through the embryonic chambers; 2, 3, vertical sections of three specimens, one through an embryonic chamber. Specimens from locality J. 20 M.

4–5.—*Discocyclina perkinsi* Vaughan, n. sp. 4, section nearly horizontal, passes through a part of the equatorial layer and shows the annuli of the chambers, but the chambers are very small and probably cannot be distinguished in the reproduction; 5, vertical section through the embryonic chambers. Specimens from locality J. 59 M.

Plate 47

Figs. 1–6.—*Lepidocyclina* (*Pliolepidina*) *kinlossensis* Vaughan, n. sp. 1, 2, 3, vertical sections, 2 and 3 through embryonic chambers; 4, an oblique section through the embryonic chambers; 5, equatorial chambers; 6, an oblique section that cuts the equatorial plane. Specimens from locality J. 14 M.

PLATE 48

FIGS. 1–2.—*Lepidocyclina*, sp., cf. *L.* (*Nephrolepidina*) *perundosa* Cushman. Vertical sections of two specimens from locality J. 58 M.

3.—Specimens from locality J. 43 M. The *Lepidocyclina* appears to be a very selliform specimen of *L.* (*Nephrolepidina*) *undosa* Cushman cut near the edge, and within the curvature of it is a specimen of *Miogypsina*, perhaps *M. bracuensis* Vaughan, n. sp. Locality J. 43 M. represents the Montpelier white limestone. The specimen here figured indicates an age not older than Oligocene.

4–8.—*Lepidocyclina* (*Lepidocyclina*) *sherwoodensis* Vaughan, n. sp. 4, 5, 8, vertical sections; 6, horizontal section through embryonic chambers; 7, horizontal sections through embryonic and equatorial chambers. Specimens from locality J. 57 M.

PLATE 49

FIGS. 1–4.—Specimens from locality J. 56 M. described as a variant of *Lepidocyclina* (*Lepidocyclina*) *canellei* Lemoine and R. Douvillé. 1, horizontal section through the embryonic chambers; 2, 3, 4, vertical sections.

5.—Specimen, apparently microspheric, from locality J. 56 M., tentatively referred to *L. canellei*. The section is nearly vertical but does not pass through the center.

6.—Specimen from J. 56 M., probably the same species as the foregoing, but it has pillars and on the surface papillae.

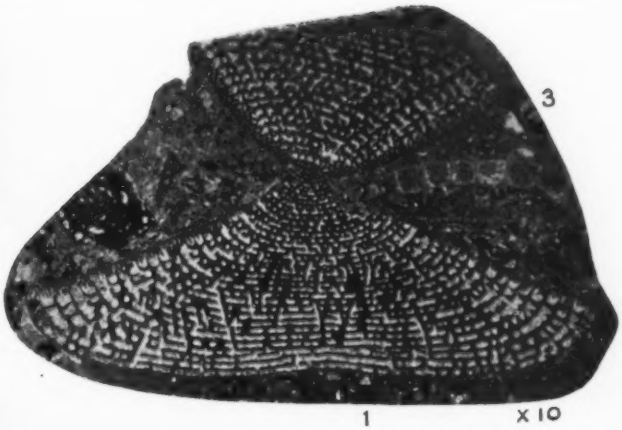
7–9.—*Lepidocyclina* (*Lepidocyclina*) *canellei* Lemoine and R. Douvillé. 7, 9, vertical sections of specimens from locality J. 26 M.; 8, vertical section of specimen from J. 29 M.

10–13.—*Lepidocyclina* (*Lepidocyclina*) *trinitatis* H. Douvillé. 10, 11, specimens from locality J. 11 M.: 10, vertical section through embryonic chambers; 11, oblique section through the embryonic chambers. 12, 13, specimens from locality J. 65 M., vertical sections: 12, macrospheric individual; 13, microspheric individual.

PLATE 50

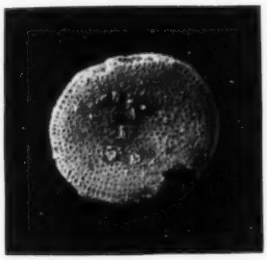
FIGS. 1, 2.—*Lepidocyclina* (*Nephrolepidina*) *haddingtonensis* Vaughan, n. sp. 1, vertical sections through three specimens, one macrospheric, two microspheric; 2, oblique section through specimen shows nephrolepidine embryonic chambers, also shows vertical sections of *Asterocyclina*. (See pl. 44, fig. 4.) Specimens from J. 67 M.

4a x 5

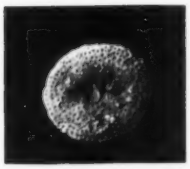


3

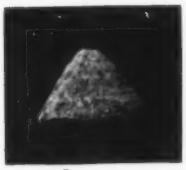
1 x 10



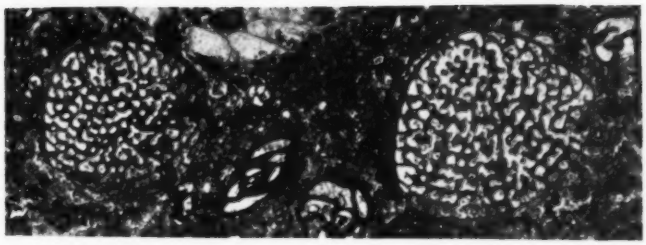
4b x 5



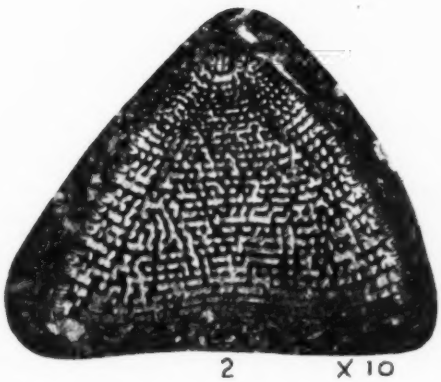
5a x 5



5b x 5

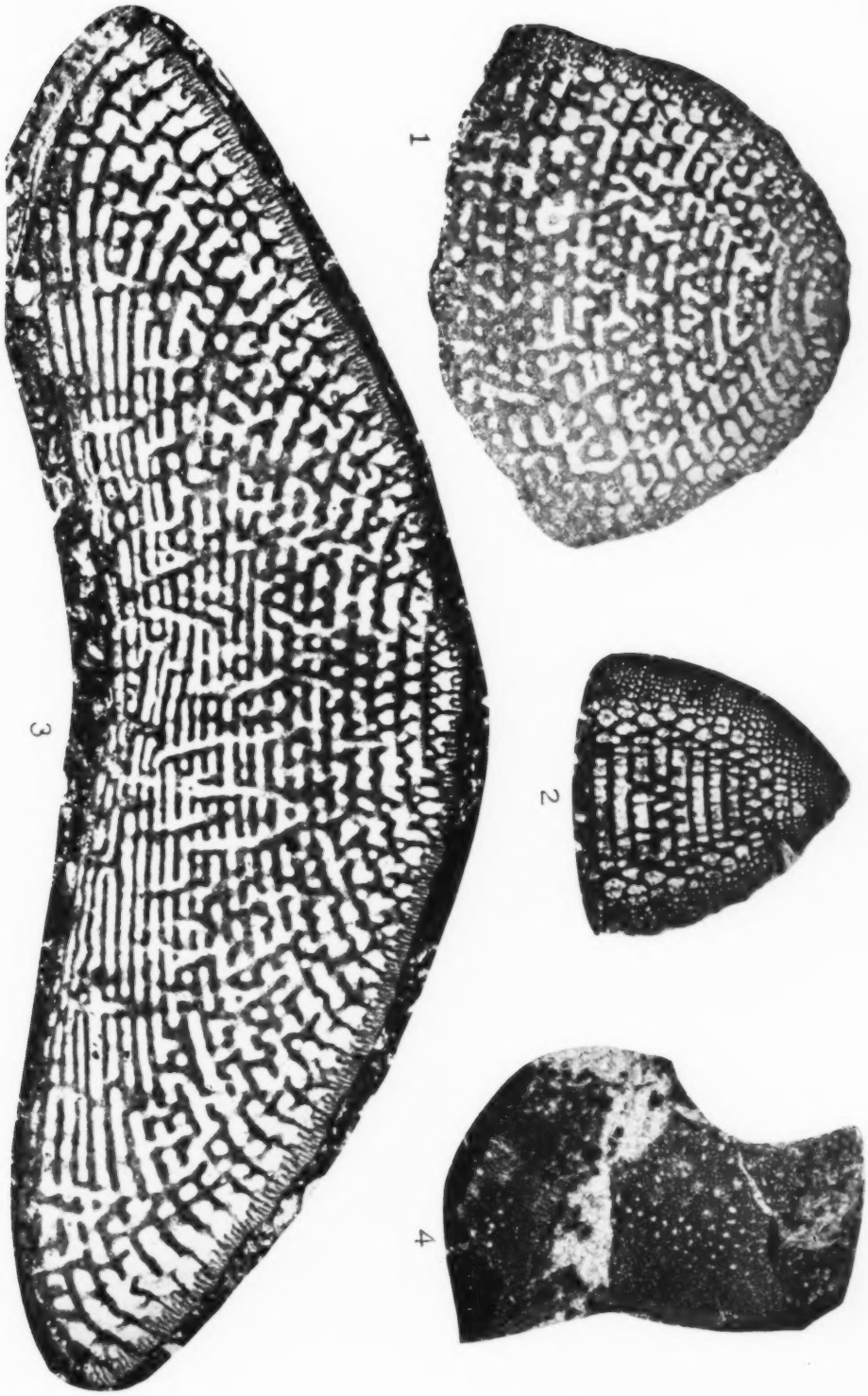


7 x 10

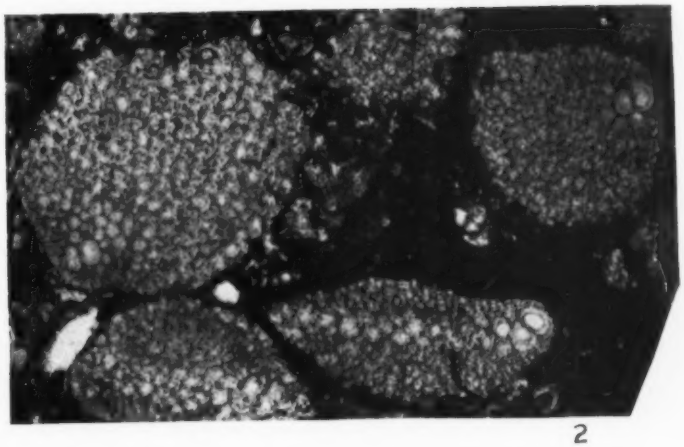


2 x 10

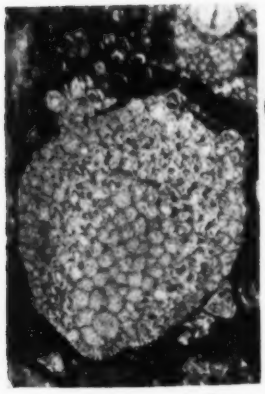
6 x 20


1
2
3
4

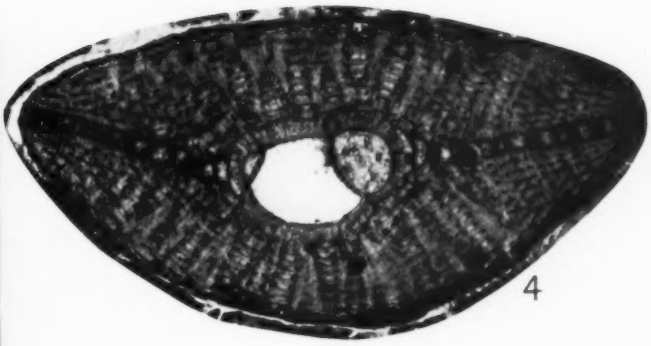
1



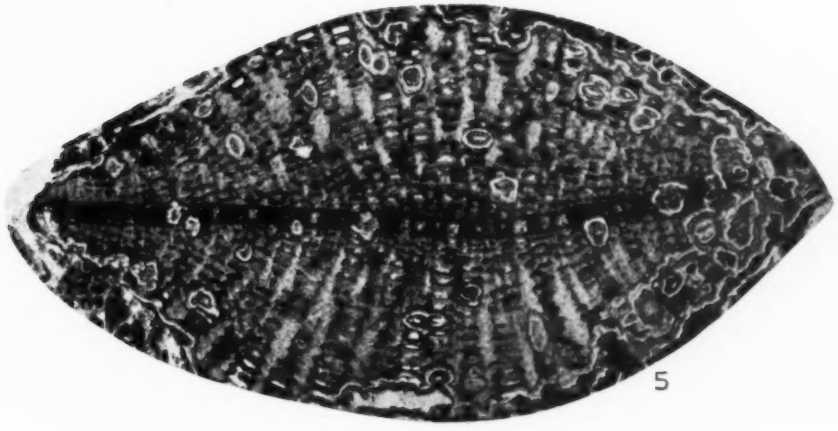
2



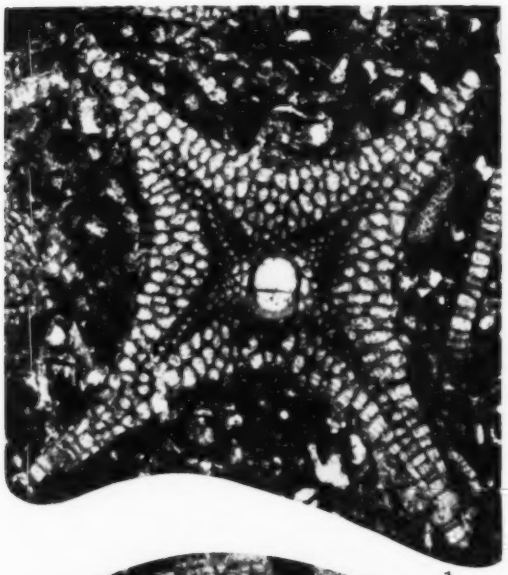
3



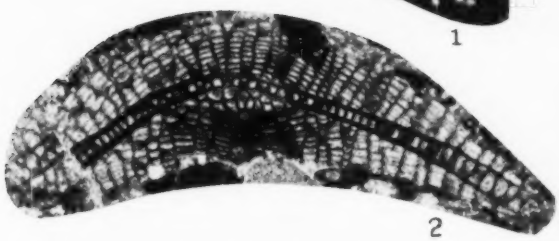
4



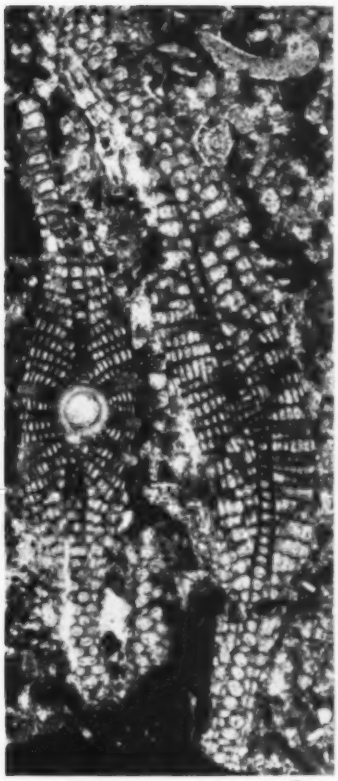
5



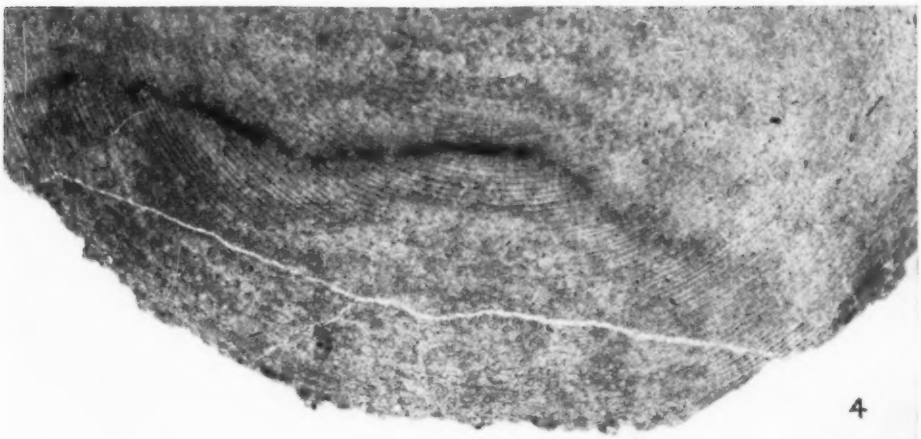
1



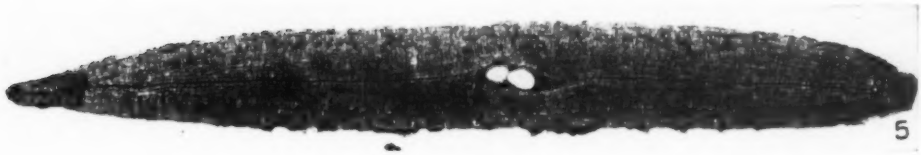
2



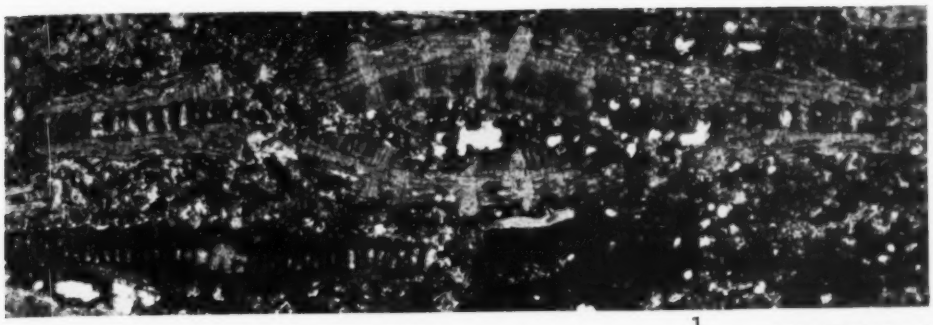
3



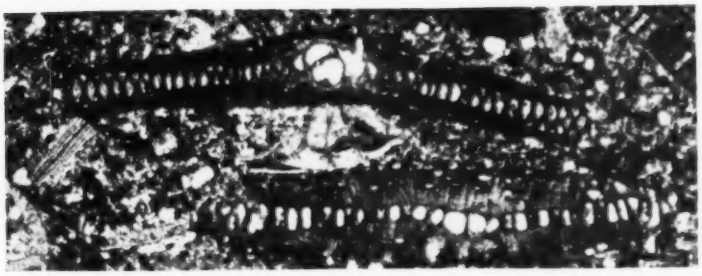
4



5



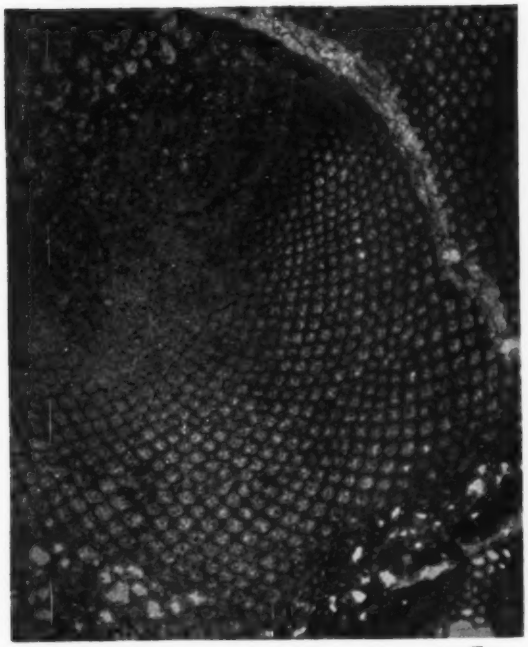
1



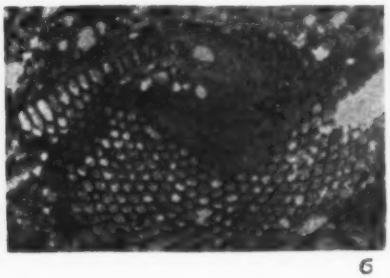
2

3

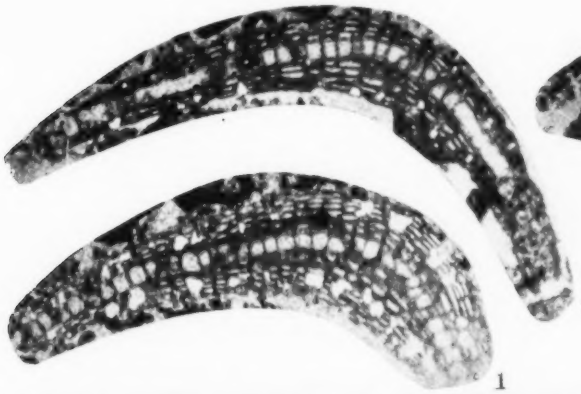
4



5

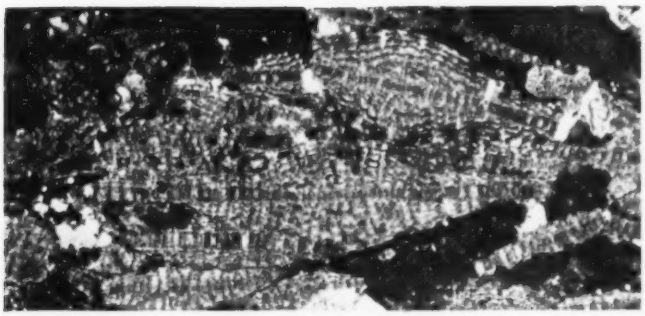


6

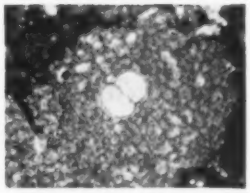


1

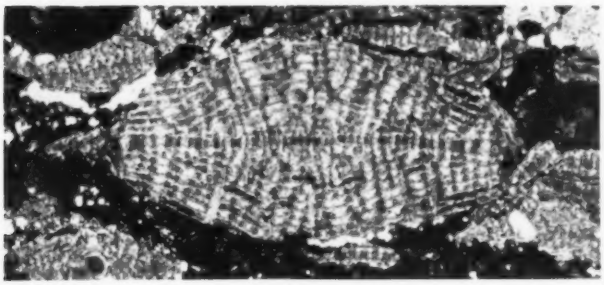
3



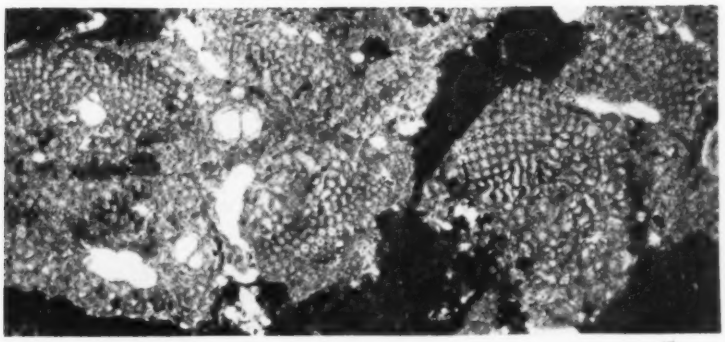
4



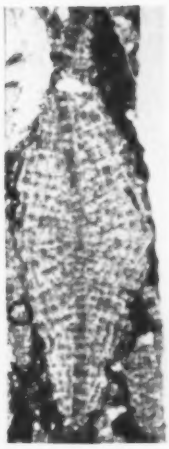
6



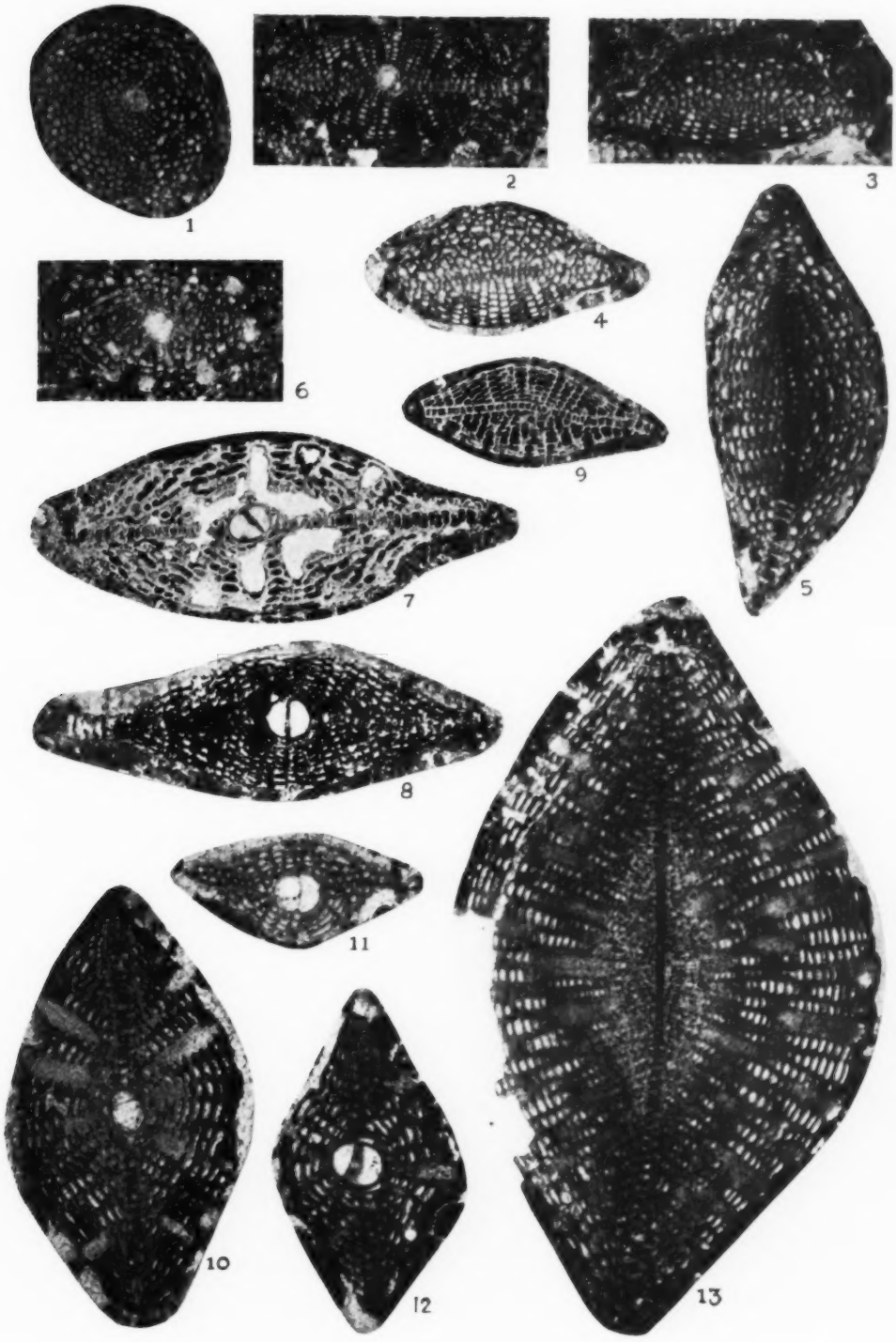
5

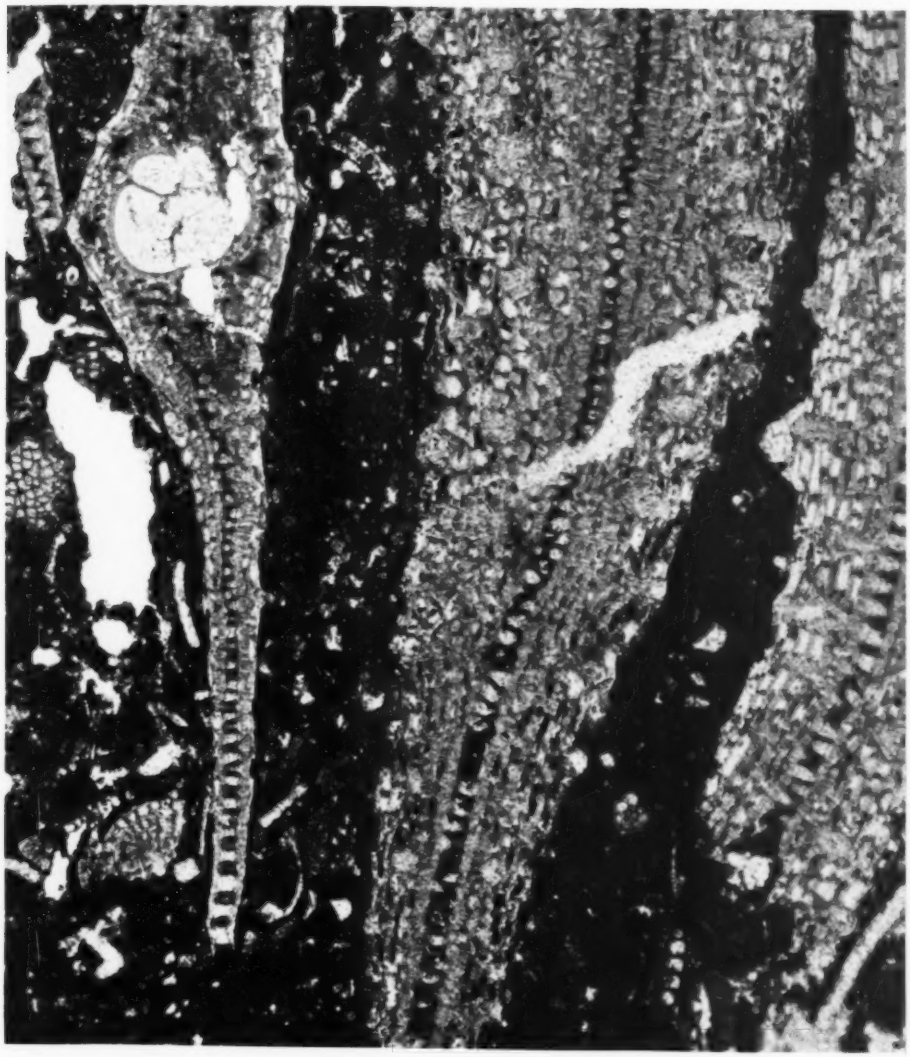


7

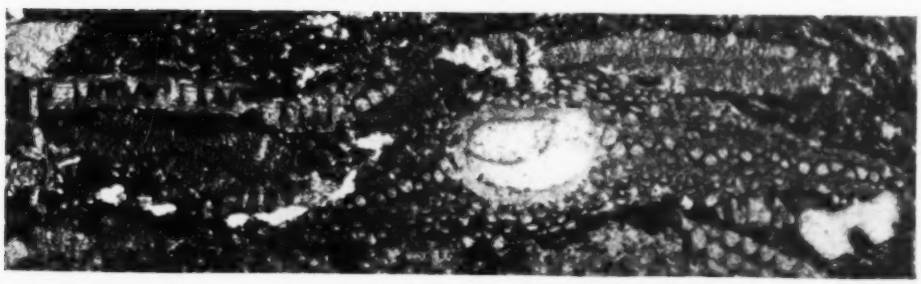


8


1
2
3
4
5
6
7
8
9
10
11
12
13



1



2

NOTES ON THE GENUS *POLYLEPIDINA* AND A NEW SPECIES

J. J. GALLOWAY
New York City

The genus *Polylepidina* was erected by Vaughan (*Bull. Geol. Soc. Amer.*, vol. 35, 1924, p. 794) as a subgenus of *Lepidocyclina* (the correct name of which is *Cyclosiphon*). *Polylepidina* is more primitive than *Cyclosiphon* or any of its four subgenera (*Cyclosiphon*, *Nephrolepidina*, *Amphilepidina*, and *Eulepidina*), but is not ancestral to *Cyclosiphon*, which was derived from *Lepidorbitoides;* nor was it derived from any of them. Therefore, *Polylepidina* should be recognized as a separate genus. It is the most primitive genus of the *Orbitoidinae*, excepting *Helicolepidina;* and its occurrence in the Cretaceous is of special interest.

Polylepidina is characterized by having a planispiral nucleoconch, in both megaspheric and microspheric forms, and arcuate median chambers. Although Vaughan does not consider that the chambers of the nucleoconch are arranged in a perfect spiral, he does recognize an indistinct spiral in *P. proteiformis* Vaughan (*op. cit.*, p. 811). I have several species of *Polylepidina* which agree with the type (*P. chiapasensis* Vaughan) in all respects excepting that the megaspheric nucleoconch is perfectly spiral. It does not seem reasonable that Vaughan could have failed to recognize the spiral condition of the nucleoconch, so his specimens must be considered as representing an intermediate stage between the perfectly spiral nucleoconch and the condition in *Pliolepidina*, where one very large central chamber is surrounded by several smaller ones irregularly arranged. The spiral condition frequently is not apparent in the thin section, but it can be seen as the section is being ground down.

Rather than to erect another genus for such a slight difference and further to complicate the nomenclature of a family already overburdened with forty-three generic names, it is thought best to enlarge the definition of *Polylepidina* to include species with perfectly planispiral, megaspheric nucleoconchs.

Inasmuch as no categorical definition of *Polylepidina* has appeared, the following diagnosis is offered:

Genus POLYLEPIDINA Vaughan, 1924

Plate 51, figs. 1-6

Genoholotype *Polylepidina chiapasensis* Vaughan = *Lepidocyclina* (*Polylepidina*) *chiapasensis* Vaughan, *Bull. Geol. Soc. Amer.*, vol. 55, 1924, pp. 794, 807, pl. 30, figs. 1–3, text-fig. 4. (Eocene, 7 km. southeast of Chilon, Chiapas, Mexico,)

Test discoidal, biconvex, varying to flat on one side and conical on the other; surface pustulose to nearly smooth; test consisting of a median zone of chambers,

one chamber thick, and two lateral zones of chambers, with or without pillars; median chambers arcuate (pl. 51, fig. 2), with curved outer wall and pointed or truncate proximal ends (as in *Orbitoides*), the adjacent chambers of the same annulus just touching and arranged in intersecting, radial curves, or not touching and arranged in radial lines (*P. antillea* [Cushman]) and appearing diamond-shaped in thick or opaque sections, with longer diameter parallel to the periphery of the test; there are foramina at the bases of the arcuate walls which connect adjacent chambers of the same annulus and of those of the succeeding annulus, but the arcuate wall appears to be otherwise imperforate (fig. 1). The arcuate wall consists of a thin, dark layer which is minutely granular, on each side of which is a thick, light-colored layer made up of fibers which are at right angles to the dark layer. There are no tubular pores, as occur in the walls of the lateral chambers. The lateral walls of the median chambers are sometimes clearly perforate.

The lateral chambers completely cover the median zone of chambers or are missing near the periphery of the test, are arranged in layers and in tiers, and have finely perforate walls in some species, in others apparently imperforate; sometimes the lateral chamber cavities are missing and the layers of walls are directly superimposed.

The microspheric nucleoconch consists of a minute, spherical proloculum and succeeding chambers which gradually enlarge, making two or three volutions, and gradually changing in shape from that of a sector to that of an arc, the outer walls of the sector-shaped chambers being much thicker than the walls of the succeeding, arcuate chambers (fig. 2). Diameter of proloculum, about 0.035 mm.; of nucleoconch, about 0.2 mm.

The megaspheric nucleoconch consists of a large, globular proloculum succeeded by three to seven large, but gradually decreasing, arcuate chambers arranged in nearly a complete coil and passing gradually into the normal, arcuate, median chambers (fig. 3). The nucleoconch is not separated from the succeeding chambers by any common, thick wall, but the outer walls of the first two or three chambers is much thicker than those of the succeeding chambers. Diameter of proloculum, from 0.14 to 0.5 mm;. of nucleoconch, from 0.25 to 0.7 mm.

Diameter of test, 2–20 mm.; the microspheric form is several times larger than the megaspheric form.

Occurrence.—Upper Cretaceous near Cardenas, Mexico; Eocene of Chiapas, Mexico; Upper Eocene of Vera Cruz, Mexico, and of Alabama, Mississippi, Louisiana, and the Antilles.

The known species of *Polylepidina* are as follows:

Polylepidina chiapasensis Vaughan (Vaughan, *op. cit.*, p. 808). Eocene, Chiapas.

P. adkinsi Vaughan (*ibid.*, p. 809). Eocene, Chiapas.

P. proteiformis Vaughan (*ibid.*, p. 810). Eocene, Mecapala, Vera Cruz.

P. antillea (Cushman) (Vaughan, *ibid.*, p. 821). Upper Eocene, Saint Bartholomew, West Indies.

P. mortoni (Cushman) (*U.S. Geol. Surv. Prof. Paper 125* [*D*], 1920, p. 70.) Upper Eocene, Ocala of Alabama and Jackson of Mississippi.

P., sp. undes. Eocene, Claiborne. La Salle Parish, Louisiana.

P. cardenasensis, n. sp. (described below).

Similarities and Differences

Polylepidina is very similar to several other genera of orbitoids, and close discrimination is necessary for their recognition.

In *Orbitoides* the median chambers are arcuate, but the megaspheric nucleoconch is quadrilocular, the four chambers being surrounded by a common wall. The microspheric form has not been described, but it probably will be indistinguishable from that of *Polylepidina*.

In *Clypeorbis*, which is typically conical in shape, the megaspheric nucleoconch is spiral but the median chambers are spatulate (curved on the outer surface but with parallel sides) to subhexagonal.

In *Pseudorbitoides* Douvillé (*C. R. Somm., Séan. Soc. Géol. France*, December 18, 1922, p. 203, fig. 1) the microspheric nucleoconch is planispiral, the median chambers are arcuate and in radial lines, but the median zone consists of three layers of chambers in the mature portion of the test. If the multiple layers of median chambers be not considered as of generic importance, as not considered by Vaughan (*op. cit.*, p. 796) for *Multicyclina duplicata* Cushman, then *Polylepidina* becomes a synonym of *Pseudorbitoides*.

In *Lepidorbitoides* the megaspheric nucleoconch is bilocular and the median chambers are spatulate. It is very close to and probably ancestral to *Cyclosiphon*. *Lepidorbitoides* was probably derived from *Polylepidina*.

In *Pliolepidina* the nucleoconch is apparently not spiral and the median chambers are spatulate to ogival (like a pointed arch or bullet) in shape.

In *Cyclosiphon* and its subgenera the megaspheric nucleoconch is bilocular and the median chambers are spatulate to ogival in shape.

In *Helicolepidina* the whole test is spiral, and if ever found in the Cretaceous, would be considered as the ancestral form of all the other *Orbitoidinae*.

In *Miolepidocyclina*, of the Oligocene and Miocene, both the microspheric and megaspheric nucleoconchs are planispiral, as in *Polylepidina*, but the median chambers are spatulate to ogival in shape.

The shape of the median chambers, which appears to be the same for both microspheric and megaspheric forms in the respective genera, and a consideration of the horizon in which the genera are known to occur are the most reliable characters for recognition of the genera of orbitoids with the microspheric form. The character of the megaspheric nucleoconch and the shape of the median chambers are sufficient for recognition of all the fifteen good genera and subgenera of *Orbitoidinae*. It seems that the microspheric form of all the genera of *Orbitoidinae* are spiral.

A New Species of Polylepidina

POLYLEPIDINA CARDENASENSIS Galloway, n. sp.

Test discoidal, equilateral, not sellaeform; megaspheric form 2–5 mm. (av., 3 mm.) in diameter and 0.5 mm. or less in thickness; microspheric form unknown; surface finely pustulose; median chambers arcuate in shape, with pointed proximal ends, 0.14 mm. long tangentially to the test, and 0.07 mm. wide radially to the test, in the mature portion of the test, and about half that size near the nucleoconch.

The median zone increases in thickness from 0.035 mm. at the center to 0.14 mm. at the periphery of the test.

The lateral zones consist of from three to ten layers of chambers in more or less regular tiers, the chamber cavities being about twice as thick as the walls. The lateral chambers, as seen in parallel sections, are polygonal, of varying sizes and shapes. As seen in vertical sections, the lateral chambers of one tier alternate with those of adjacent tiers; each chamber communicates by slitlike openings with the next lower and higher chambers of adjacent tiers. The wall of the lateral chambers appear to be imperforate. Between the tiers of lateral chambers are small pillars, some of which extend from the median zone to the surface; others start nearer the surface and do not increase much in size.

The megaspheric proloculum is nearly spherical in shape, and from 0.14 to 0.2 mm. in diameter. The megaspheric nucleoconch consists of about eight chambers arranged in a flat spire. The second chamber is shaped like three-fourths of a circle, the third chamber is semicircular, and the succeeding chambers are arcuate. The chambers make one complete whorl, gradually decreasing in size and merging into the other median chambers. The walls of the chambers of the nucleoconch decrease in thickness from the proloculum to the end of the first whorl.

Median sections which do not cut exactly through the center of the nucleoconch show the indistinct spiral or cyclical or four-leaf-clover effect of *Polylepidina proteiformis* Vaughan (*op. cit.*, p. 811).

No microspheric specimens have been found, although megaspheric specimens occur in inconceivable numbers.

Cotypes: Columbia University Paleon. Coll., No. 19873.

Occurrence.—Near the railroad, 1 kilometer east of the railway station at Cardenas, San Louis Potosi, Mexico, *Polylepidina cardenasensis* makes up a bed of limestone 20 feet thick; enormous numbers occur in the shales above (east of) the limestone. The limestone dips to the east about 60° and is overlain by shales which grade into sandstones which stand vertically. The sandstones ½ kilometer farther east carry a typical Upper Cretaceous fauna of Mollusca, of Senonian age, described by Böse (*Bol. Inst. Geol. Mexico*, no. 24, 1906). The *Polylepidina* bed appears to be at least 3,000 feet below the top of the Upper Cretaceous of that locality. Very few other fossils occur with the *Polylepidina;* only an undetermined

FIG. 1

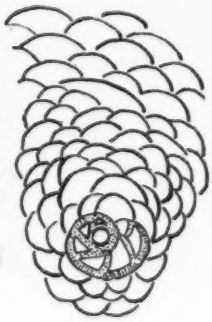


FIG. 2

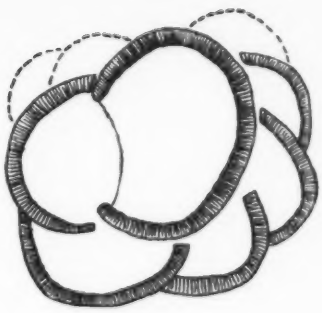
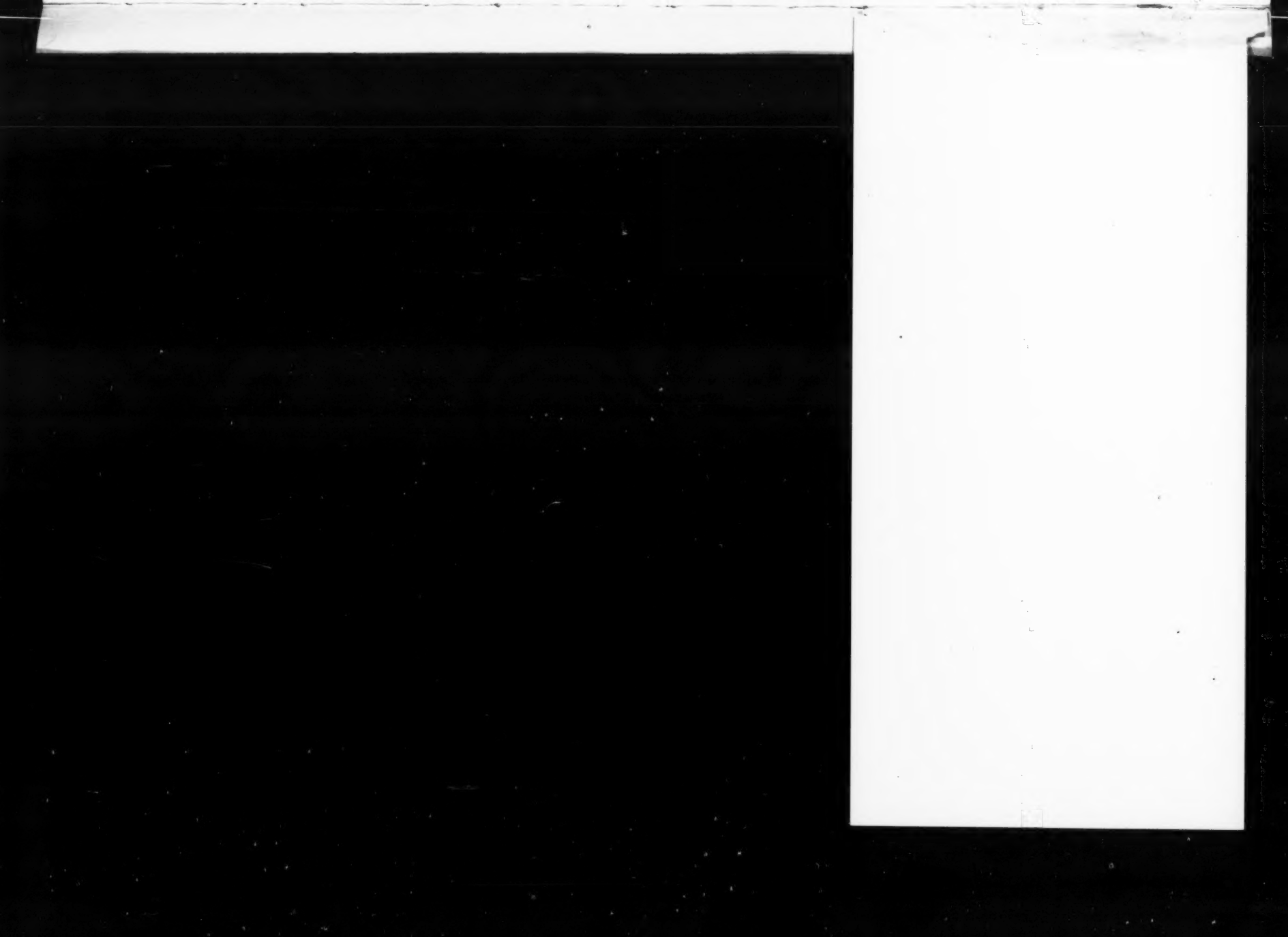


FIG. 3

Insert in Galloway article, opposite p. 303, JOURNAL OF PALEONTOLOGY
Vol. I, No. 4, January, 1928



bryozoan, a species of *Bairdia*, a *Cibicides*, a *Rotalia*, and *Gümbelina globulosa* (Ehrenberg) have been noted. The rocks about Cardenas have been highly folded, so that it is difficult to tell which way is stratigraphically up; but because Lower Cretaceous limestone occurs west of Cardenas and because of the position of the Mollusca and the character of the cross-bedding in the beds east of the foraminiferal beds I have concluded that stratigraphically up is eastward and that the *Polylepidina* is therefore much below the top of the Cretaceous. It can scarcely be Eocene, for no Eocene rocks are known from that part of Mexico.

The age of the *Polylepidina* bed is an important point, for *Polylepidina* has heretofore been found only in the Eocene.

Douvillé has noted the occurrence of this orbitoid (*Bull. Soc. Géol. France*, ser. 4, vol. 23, 1923, p. 370) and compared it with *Pseudorbitoides trechmanni* from the Upper Cretaceous of Jamaica, and suspects that they are the same thing. The specimens of *Pseudorbitoides* figured by Douvillé (*ibid.*, p. 369) are microspheric, and there are two and three layers of chambers in the outer part of the median zone; the specimens are larger, but they are otherwise very similar. *Polylepidina cardenasensis* and *Pseudorbitoides trechmanni* may be the megaspheric and microspheric forms of the same species; but until the megaspheric form of *Pseudorbitoides* or the microspheric form of *P. cardenasensis* are found and their identity established, the two forms must be considered both generically and specifically distinct.

EXPLANATION OF TEXT-FIGURES

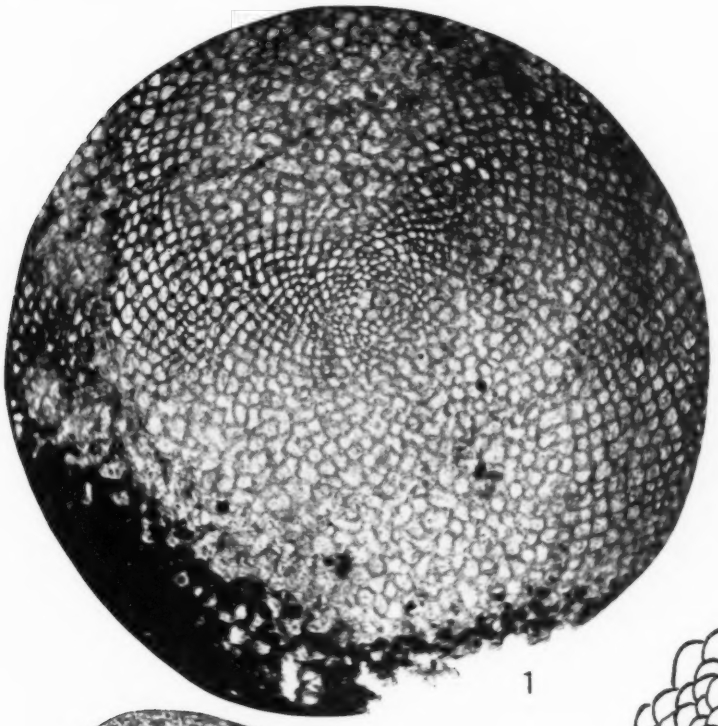
FIG. 1.—Some of the later, median chambers of a microspheric specimen of *Polylepidina mortoni* (Cushman), to show their arcuate shape, their arrangement and structure, and the foramina. ×60. Jackson Eocene, 5 miles north of Geneva, Alabama.

FIG. 2.—The microspheric nucleoconch and some of the median chambers of *Polylepidina mortoni* (Cushman). ×60. Same locality as for figure 1, another specimen.

FIG. 3.—The megaspheric nucleoconch of *Polylepidina mortoni* (Cushman), to show the relative size, the shape, and spiral arrangement of the chambers. ×60. Same locality as for figure 1.

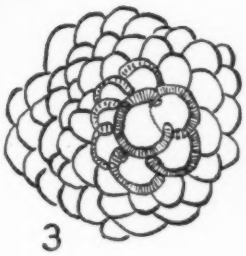
EXPLANATION OF PLATE 51

FIGS. 1–6.—*Polylepidina cardenasensis* Galloway, n. sp. Cotypes, from 1 km. east of Cardenas, San Louis Potosi, Mexico. Upper Cretaceous. 1, median section showing the coiled, megaspheric nucleoconch, the arcuate median chambers, and polygonal lateral chambers; ×30. 2, A few median chambers in the outer portion of the test, showing their arcuate shape, the three layers of which they are composed, and basal foramina; from the same specimen as figure 1; ×80. 3, The spiral nucleoconch and a few of the median chambers; same specimen as figure 1; ×80. 4, Parallel section of lateral chambers showing their irregular shape and the small pillars; from the same specimen as figure 1; ×80. 5, Surface of another specimen; ×15. 6, Vertical section of two other specimens; ×30.

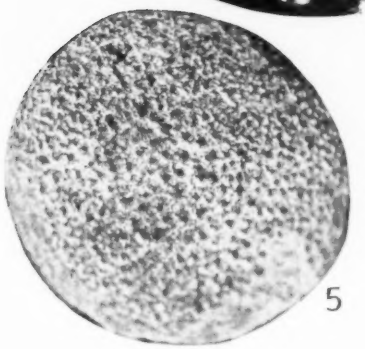


1

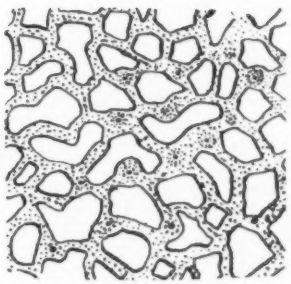
2



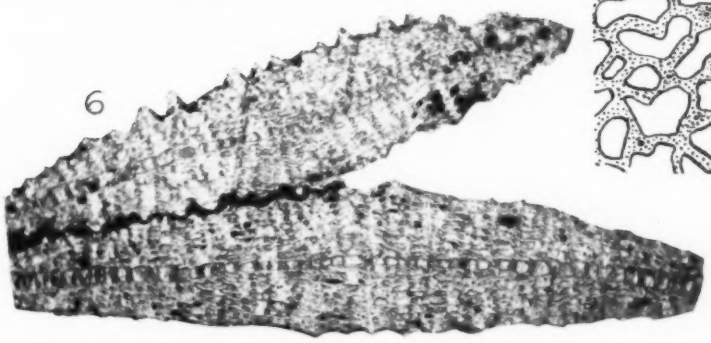
3



5



4



6

PENNSYLVANIAN FORAMINIFERA OF OKLAHOMA AND TEXAS

BRUCE H. HARLTON[1]
Amerada Petroleum Corporation, Tulsa, Oklahoma

Order FORAMINIFERA

Family AMMODISCIDAE

Genus TOLYPAMMINA Rhumbler, 1895

TOLYPAMMINA GRAHAMENSIS Harlton, n. sp.

Plate 52, fig. 1

Test adherent, with round, coiled proloculum and a long, irregularly coiling tube; irregular growth-lines visible on tube; wall finely arenaceous; aperture single, simple, terminal. Smallest diameter of the tube of holotype, 0.08 mm.; largest diameter, 0.28 mm.

Graham formation, at cut in Rock Island R.R. at Perrin road crossing, 3 miles southeast of Jacksboro, Jack County, Texas. Holotype, U.S. National Museum Coll., No. 71721.

This form is usually attached to a fragment of a brachiopod. The surface of the test is finely granular. In most cases the granules are so minute and regular as to be readily mistaken for perforations. The early stages of the test are peculiarly constructed and often obscured. *T. grahamensis* is a very widespread form both in Oklahoma and Texas. It has been found only in the upper Pennsylvanian strata.

Genus GLOMOSPIRA Rzehak, 1888

GLOMOSPIRA SIMPLEX Harlton, n. sp.

Plate 52, figs. 2*a–c*

Test free, trochoid, nearly round, peripheral margin rounded, with subcircular or ovoid proloculum and a long undivided second chamber, at first planispiral but soon becoming irregular; wall finely arenaceous with a large proportion of cement; aperture round, simple, terminal. Diameter of holotype, 0.33 mm.

Gaptank formation,[2] according to Robert and Phillip King, 1½ miles northeast of Wolfcamp 450 feet below upper Gaptank. Pecos County, Texas. Holotype, U.S. National Musuem Coll., No. 71722.

This minute form is fairly constant in its specific character. The surface is very finely granulated and the tubular chamber is often marked by slight transverse markings.

[1] Published by permission of the Amerada Petroleum Corporation. The writer wishes to express appreciation for careful criticism to Professor J. J. Galloway.

[2] The fossils found at this locality suggest Dimple age and not Gaptank.

Family NONIONIDAE

Genus ENDOTHYRA Phillips, 1846

ENDOTHYRA ROTHROCKI Harlton, n. sp.

Plate 52, figs. 3 *a*, *b*

Test free, nautiloid, nearly symmetrically bilateral, periphery rounded, umbilici depressed; chambers numerous, usually nine; sutures distinct, limbate, slightly depressed; wall calcareous, smooth; aperture a curved small slit at the base of the apertural face. Diameter of holotype, 0.38 mm.

Graham formation, at cut in Rock Island R.R. at Perrin road crossing, 3 miles southeast of Jacksboro, Jack County, Texas. Holotype, U. S. National Museum Coll., No. 71723.

This form differs from *E. globulus* d'Eichwald in the distinct umbilici and the slight depression of the sutures along the peripheral margin. Specimens collected from various localities did not exceed nine chambers, while *E. globulus* varies from ten to fourteen chambers.

Genus BRADYINA Möller, 1878

BRADYINA MARATHONENSIS Harlton, n. sp.

Plate 52, figs. 6 *a*, *b*

Test free, planispiral, nautiloid, laterally asymmetrical, peripheral margin rounded; chambers numerous, usually seven; sutures limbate, slightly curved, slightly depressed, and each usually provided with eight small indistinct, round pores; wall calcareous; aperture curved opening at the base of the last chamber. Diameter of holotype, 0.27 mm.

Gaptank formation, according to Robert and Philip King, 1½ miles northeast of Wolfcamp 450 feet below upper Gaptank, Pecos County, Texas. Holotype, U. S. National Museum Coll., No. 71724.

This distinct little form is very common at the type locality. The sutures are somewhat depressed, and the pores are indistinct. The chambers are of very even character.

Genus HAPLOPHRAGMOIDES Cushman, 1910

HAPLOPHRAGMOIDES MARGA Harlton, n. sp.

Plate 52, figs. 4 *a*, *b*

Test free, planispiral, nautiloid, biconvex, complanate, much depressed, periphery very slightly rounded, umbilicate; chambers numerous, usually nine; sutures strongly limbate; wall arenaceous, siliceous, smooth; aperture a semicircular opening at the last chamber, covering almost the entire apertural face. Diameter of holotype, 0.42 mm.

Caney shale, NW. ¼ of SE. ¼ of SE. ¼ of Sec. 1, T. 3 S., R. 2 E., Carter County, Oklahoma. Holotype, U. S. National Museum Coll., No. 71725.

This species is rather rare in occurrence and has been found only in the Caney

shale of southern Oklahoma. The depressed shape of the test and the typical arenaceous wall will readily distinguish this form.

HAPLOPHRAGMOIDES CISCOENSIS Harlton, n. sp.

Plate 52, figs. 8 *a*, *b*

Test free, planispiral, nautiloid, biconvex, periphery round; chambers numerous, inflated, usually ten in the last-formed whorl; umbilici large, depressed; sutures distinct; wall arenaceous, siliceous, smooth; aperture semicircular occupying almost the entire apertural face. Diameter of holotype, 0.48 mm.

Cisco formation, $4\frac{1}{2}$ miles west of Cisco on main Cisco-Abeline road, Eastland County, Texas. Holotype, U. S. National Museum Coll., No. 71726.

The large umbilici and the strongly inflated chambers are most characteristic of the species. In the umbilici on which some of the chambers of the previous whorl are visible is sometimes noted.

Family FUSULINIDAE

Genus STAFFELLA Ozawa, 1925

STAFFELLA TEXANA Harlton, n. sp.

Plate 52, figs. 5 *a–c*

Test free, large and stout, planispiral, umbilicate, periphery round and thick, chambers numerous, usually eighteen; sutures very distinct, depressed; wall calcareous, smooth; aperture single, large at the apertural face. Diameter of holotype, 1.58 mm.

Graham formation, at cut in Rock Island R. R. at Perrin road crossing, 3 miles southeast of Jacksboro, Jack County, Texas. Holotype, U. S. National Museum Coll., No. 71727.

The gradual increase in size and inflation of the later chambers is a feature easily recognized. The surface is in most cases covered with course fragments of silica.

STAFFELLA FORMOSA Harlton, n. sp.

Plate 52, figs. 7 *a–c*

Test free, planispiral, non-umbilicate, periphery slightly rounded, sometimes acute, chambers numerous, usually nineteen; sutures distinct, limbate; wall calcareous, smooth; aperture single, large, at the apertural face. Diameter of holotype, 0.62 mm.

Cisco formation, $4\frac{1}{2}$ miles west of Cisco, on main Cisco-Abeline road, Eastland County, Texas. Holotype, U. S. National Museum Coll., No. 71728.

This species is characterized by its lenticular shape, convex on both sides. The suture lines fall into two groups; the primary group end along a transverse ridge, while the secondary ones end on the primary ones not necessarily at the center of the test.

STAFFELLA CISCOENSIS Harlton, n. sp.

Plate 52, figs. 9 *a–c*

Test free, very small, closely coiled, biconvex, chambers numerous, peripheral margin acute; sutures limbate, the thickenings developed in a raised clear ridge;

wall calcareous, smooth; aperture single, large, at the apertural face. Diameter, 0.35 mm. more or less.

Cisco formation, 4½ miles west of Cisco, on main Cisco-Abilene road, Eastland County, Texas. Cotype, U. S. National Museum Coll., No. 71729.

This minute organism is characterized by its hyaline texture and the curved suture lines which in most cases are indistinct. The surface appears to be finely perforate. This form is very common at the type locality.

Genus CRIBROSTOMUM Möller, 1879

CRIBROSTOMUM CUSHMANI Harlton, n. sp.

Plate 53, figs. 3 *a–c*

Test free, rather short and very stout, elongated, tapering; chambers numerous, usually sixteen, the later ones are especially broad and inflated; sutures depressed; wall arenaceous, smooth; aperture cribriform, circular, numerous, filled with material and somewhat obscured. Length, 1.2–1.8 mm.; width, 1.0–1.7 mm.

Middle Kickapou Falls limestone of the Milsap formation (Strawn), 13 miles south of Weatherford, Parker County, Texas. Cotype, U. S. National Museum Coll., No. 71730.

This species resembles *Cribrostomum jeffersonensis* Harlton but differs considerably in that it is larger and stouter. The strong inflation of the later chambers as well as the conical shape of the test are especially characteristic. The surface is in most cases covered with coarse fragments of silica.

CRIBROSTOMUM ATTENUATA Harlton, n. sp.

Plate 53, figs. 2 *a*, *b*

Test free, elongate, slightly tapering; chambers numerous, usually twelve; sutures depressed; wall arenaceous; smooth; aperture cribriform, numerous, filled with material and somewhat obscured. Length of holotype, 1.18 mm.

Cisco formation, 4½ miles west of Cisco, on main Cisco-Abeline road, Eastland County, Texas. Holotype, U. S. National Museum Coll., No. 71731.

The elongate shape of the test makes this form easily recognizable.

Genus GLOBIVALVULINA Schubert

GLOBIVALVULINA GAPTANKENSIS Harlton, n. sp.

Plate 53, figs. 3 *a–c*

Test free, oblong, rounded, strongly inflated, subspherical, gradually increasing in size, six visible from the peripheral and dorsal side, only three from below; inferior surface flat, slightly depressed near the aperture; wall calcareous, smooth; aperture curved opening into the umbilicus. Diameter, 0.4–0.6 mm.

Gaptank formation, 4 miles west of Marathon, along railroad cut near mile post 580, Pecos County, Texas. Cotype, U. S. National Museum Coll., No. 71732.

The ventral surface of this species shows a regular depression near the aperture, while *Globivalvulina bulloides* (H. B. Brady) is irregularly depressed at the

umbilicus. The increase in size of the successive chambers is less rapid in *G. gaptankensis* than in *G. bulloides*, and all the chambers are visible from the dorsal side. The dorsal view on *G. gaptankensis* shows the chambers more inflated than those of *G. bulloides*. The wall is calcareous and appears very finely perforate.

GLOBIVALVULINA CORA Harlton, n. sp.

Plate 53, figs. 4 *a*, *b*

Test free, more or less rounded; chambers few inflated, subspherical, each succeeding one considerably larger than its predecessor, seven visible from the apertural face; on the opposite side five visible; inferior surface slightly concave; wall calcareous, very finely perforate, smooth; aperture an arched slit into the umbilicus. Diameter of holotype, 0.46 mm.

Gaptank formation, 4 miles west of Marathon, along railroad cut near mile post 580, Brewster County, Texas. Holotype, U. S. National Musuem Coll., No. 71733.

The most characteristic feature of this species is the very rapid increase of size of the successive chambers, which are strongly inflated.

Family LAGENIDAE

Genus NODOSAROUM Rhumbler, 1913

NODOSAROUM CISCOENSIS Harlton, n. sp.

Plate 53, figs. 5 *a–c*

Test free, small, straight, elongate, slightly tapering, somewhat flattened; chambers numerous, regular in arrangement; sutures very slightly if at all depressed; wall thin, calcareous, hyaline; aperture simple, single, round, terminal. Length, 0.7 mm. more or less.

Cisco formation, 4½ miles west of Cisco on main Cisco-Abeline road, Eastland County, Texas. Cotype, U. S. National Museum Coll., No. 71734.

This species differs from *Nodosinella glabra* Cushman and Waters in the very regular arrangement of the chambers and in that the wall is calcareous and hyaline. The sutures are almost invisible, but when wet the arrangement of the chambers and the suture lines are very clear. The wall is finely perforate.

NODOSAROUM GAPTANKENSIS Harlton, n. sp.

Plate 53, figs. 6 *a–c*

Test free, comparatively small, straight or slightly curved, cylindrical, tapering; chambers numerous, usually eight; sutures distinct; wall calcareous, finely perforate; aperture single, round, terminal. Length, 0.4–0.7 mm.

Gaptank formation, according to Robert and Philip King. 1½ miles northeast of Wolfcamp, 380 feet below upper Gaptank, Pecos County, Texas. Cotype, U. S. National Museum Coll., No. 71735.

The inflated terminal chamber is very characteristic of this species.

EXPLANATION OF PLATES 52, 53

PLATE 52

FIG. 1.—*Tolypammina grahamensis* Harlton, n. sp., ×40. Attached on the surface of a fragment of a brachiopod.

2 *a–c.*—*Glomospira simplex* Harlton, n. sp., ×30. *a*, *b*, front views; *c*, apertural view.

3 *a*, *b.*—*Endothyra rothrocki* Harlton, n. sp., ×53. *a*, front view; *b*, apertural view.

4 *a*, *b.*—*Haplophragmoides marga* Harlton, n. sp., ×36. *a*, front view; *b*, apertural view.

5 *a*, *b.*—*Haplophragmoides ciscoensis* Harlton, n. sp., ×66. *a*, front view; *b*, apertural view.

6 *a*, *b.*—*Bradyina marathonensis* Harlton, n. sp., ×39. *a*, front view; *b*, apertural view.

7 *a–c.*—*Staffella formosa* Harlton, n. sp., ×34. *a*, front view; *b*, apertural view; *c*, section.

8 *a–c.*—*Staffella texana* Harlton, n. sp., ×16. *a*, front view; *b*, apertural view; *c*, section, magnified ×22.

9 *a–c.*—*Staffella ciscoensis* Harlton, n. sp., ×32. *a*, front view; *b*, apertural view; *c*, section.

PLATE 53

FIG. 1 *a–c.*—*Cribrostomum cushmani* Harlton, n. sp., ×16. *a*, *b*, front views; *c*, section.

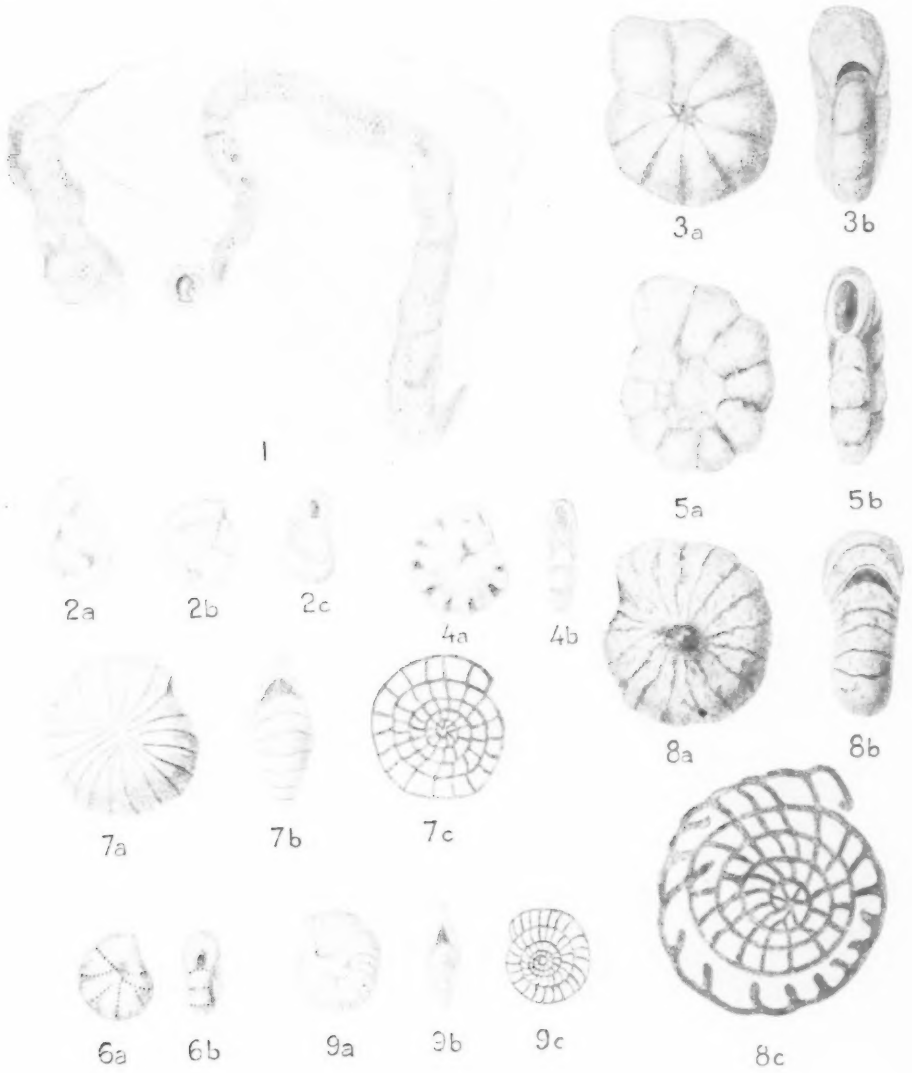
2 *a*, *b.*—*Cribrostomum attenuata* Harlton, n. sp., *a*, front view, magnified ×36; *b*, section, magnified ×32.

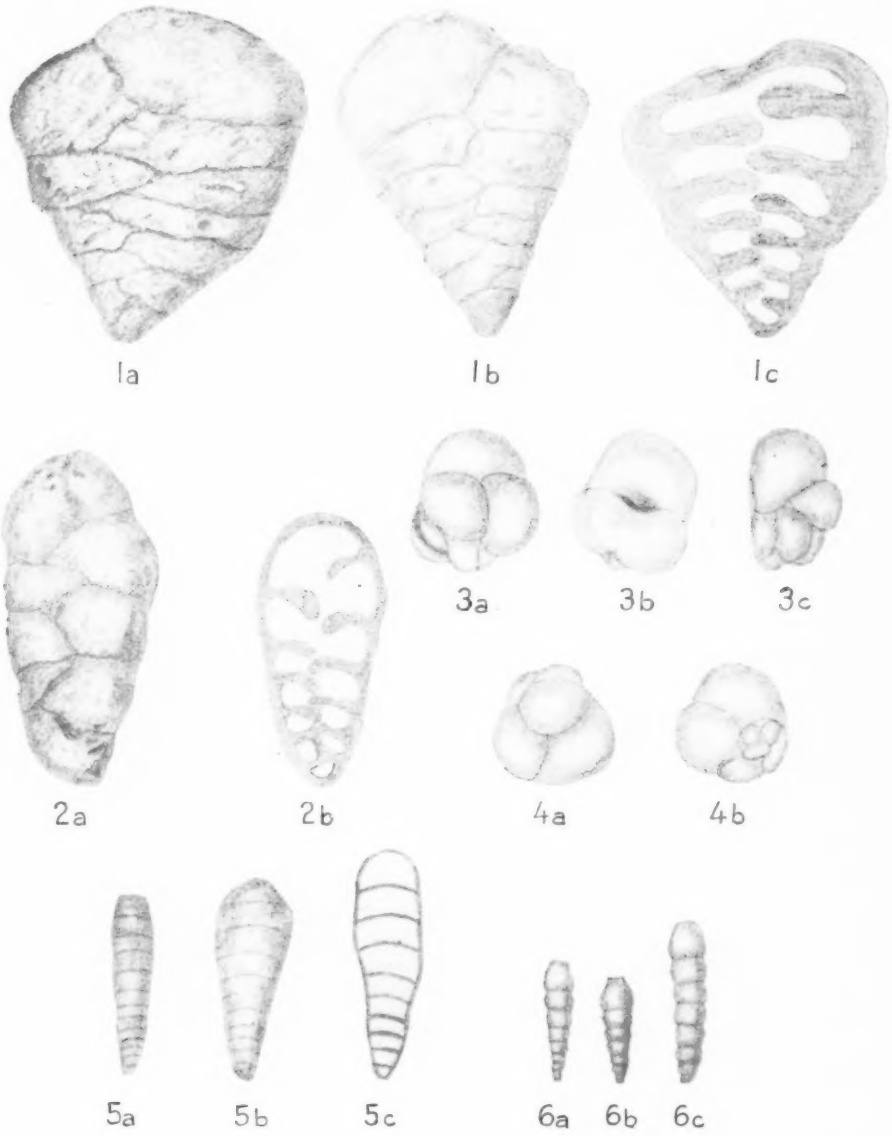
3 *a–c.*—*Globivalvulina gaptankensis* Harlton, n. sp., ×32. *a*, dorsal view; *b*, ventral view; *c*, side view.

4 *a*, *b.*—*Globivalvulina cora* Harlton, n. sp., ×32. *a*, dorsal view; *b*, ventral view.

5 *a–c.*—*Nodosaroum ciscoensis* Harlton, n. sp., ×32. *a*, *b*, side views; *b*, section.

6 *a–c.*—*Nodosaroum gaptankensis* Harlton, n. sp., ×32. *a–c*, side views.


1
2a
2b
2c
3a
3b
4a
4b
5a
5b
6a
6b
7a
7b
7c
8a
8b
8c
9a
9b
9c


1a
1b
1c
2a
2b
3a
3b
3c
4a
4b
5a
5b
5c
6a
6b
6c

REPORT OF THE FORT WORTH SECTION MEETING

W. M. WINTON

The first Southwestern paleontological field meet was successfully carried out from Fort Worth, Texas, on November 28, 29, and 30. The meet was held under the auspices of the Fort Worth Geological Society, the Fort Worth section of the Society of Economic Paleontologists and Mineralogists, and Texas Christian University.

Perfect weather conditions favored the party, which included a slightly varying group each of the three days but totaled about seventy-five.

The first day collections were made in the Cretaceous and Comanchean formations in Tarrant, Denton, and Dallas counties. The party gave special attention to the Goodland, Kiamitia, Woodbine, and Eagle Ford formations. Besides larger fossils which were collected, several hundred pounds of marl and clay samples were shipped back to their laboratories by members of the party.

The second and third days were spent in the rich Pennsylvanian formations west of Fort Worth.

The first two evenings were spent in listening to reviews of the days' trips by leaders of the party and to various discussions which arose.

The party was guided by Messrs. W. M. Winton and Gayle Scott the first day and by Mr. F. B. Plummer the second and third days. A helpful factor was a splendid road and locality map drawn by Mrs. Helen Jeanne Plummer and printed through the courtesy of the Standard Blue Print Company of Fort Worth.

A partial list of those in attendance is as follows:

Adkins, W. S., Austin, Texas
Alexander, C. I., Princeton, New Jersey
Aronson, Sam M., Dallas, Texas
Barcus, J. M., Arlington, Texas
Bentz, Ivan V., San Angelo, Texas
Bohart, F. J., Fort Worth, Texas
Brooks, Anne W., Fort Worth, Texas
Brasted, Fred, Fort Worth, Texas
Bush, F. A., Tulsa, Oklahoma
Carrell, Olleon, Fort Worth, Texas
Cheney, M. G., Coleman, Texas
Cheney, Mrs. M. G., Coleman, Texas
Creed, Buford, Dallas, Texas
Davis, S. F., Stephenville, Texas

Dorchester, C. M., Shreveport, Louisiana
Dumble, Lilian, Fort Worth, Texas
Fletcher, C. D., Shreveport, Louisiana
Griffin, Gordon, Fort Worth, Texas
Grim, Ralph E., University, Mississippi
Hanna, Marcus A., Houston, Texas
Harleton, Bruce, Tulsa, Oklahoma
Hawley, John B., Fort Worth, Texas
Hight, Claude, Fort Worth, Texas
Law, H. M., Dallas, Texas
Mahon, Margaret, Fort Worth, Texas
Martin, R. C., Fort Worth, Texas
Mix, S. E., Shreveport, Louisiana
Moreman, W. L., Clarendon, Texas
Morgan, C. G., Dallas, Texas
Moore, Bill B., Dallas, Texas
Moore, Marcus H., Fort Worth, Texas
Newman, Grace, Houston, Texas
Palmer, J. C., Fort Worth, Texas
Parker, W. S., Houston, Texas
Plummer, F. B., Fort Worth, Texas
Plummer, Helen Jeanne, Fort Worth, Texas
Redfield, John S., Norman, Cklahoma
Rice, Elmer, Fort Worth, Texas
Rolshausen, F. W., Houston, Texas
Scott, Gayle, Fort Worth, Texas
Self, Selden R., Fort Worth, Texas
Spooner, W. C., Shreveport, Louisiana
Stangl, Frank J., Fort Worth, Texas
Stiles, E. B., Fort Worth, Texas
Stone, J. A., Norman, Oklahoma
Thomas, N. L., Fort Worth, Texas
Vanderpool, D. C., Norman, Oklahoma
Weinzierl, Laura Lee, Houston, Texas
Winton, W. M., Fort Worth, Texas
Young, Karl E., Houston, Texas

REVIEW

THE EARTH AND ITS RHYTHMS.—A popular presentation of the science of geology by Charles Schuchert, professor emeritus of paleontology in Yale University, and Clara M. LeVene, research assistant in the Peabody Museum of Natural History, Yale University (D. Appleton and Company) is a most readable volume. It is a combination of well-chosen scientific facts, systematically arranged and then presented in a simple way but in beautiful language. The whole book is entertaining and can be read with profit by the specialist in geology as well as by the layman. The illustrations are well chosen, and the charts will repay careful study.

J. A. C.

SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS

OFFICERS FOR THE YEAR ENDING MARCH, 1928

J. J. GALLOWAY, *President*
New York, N.Y.

DONALD D. HUGHES, *Vice-President*
Los Angeles, California

HENRY V. HOWE, *Past President*
Baton Rouge, Louisiana

JOSEPH A. CUSHMAN, *Editor*
Sharon, Massachusetts

MARCUS A. HANNA, *Secretary-Treasurer*
Houston, Texas

EDITORIAL BOARD

G. DALLAS HANNA, San Francisco, California

JOHN B. REESIDE, JR., Washington, D.C.

P. V. ROUNDY, Washington, D.C.

L. W. STEPHENSON, Washington, D.C.

T. WAYLAND VAUGHAN, La Jolla, California